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CANDLE-POWER RATINGS.

Some discussion has arisen of late—or rather the old discussion has been renewed—regarding the proper rating of electric lamps. One side, with much show of reason, emphatically declares that the only proper rating is one based on the spherical candle-power—that is to say, the rating which is determined by the total amount of light given out by the lamp. The objection to this method of rating is that, unless very special apparatus be at hand, and be employed very carefully, the rating is apt to be not much better than one based on the mean horizontal candle-power. Moreover, with a given type of lamp and one form of filament, the relation between the mean horizontal and the mean spherical candle-powers will, in general, be close enough for commercial purposes. If lamps gave a constant output of light throughout their entire life, or if they all varied in exactly the same way, there would be greater need for more exact ratings. On the whole, however, those in favor of the spherical candle-power rating seem to have the better of the argument.

But there is another phase of the question which is often overlooked. Lamps of different types—such, for instance, as the arc and the incandescent, the Nernst and the Cooper Hewitt—do not give the same quality of light; hence, strictly speaking, even a spherical candle-power rating is not altogether satisfactory. What one wishes to know is not how much light a certain lamp gives, but how much floor space or how large a room can be satisfactorily lighted by it. As a general thing, a better distribution of light is obtained by many small units, rather than one large unit; and, on the other hand, the larger units are more economical. A spherical candle-power rating is all right when one wishes to select from many lamps of the same class; yet, if one went on the assumption that because a certain spherical candle-power with one type of lamp gave satisfactory illumination, an equivalent total amount of light, as determined photometrically, obtained in another type would give results equally satisfactory, he would often find himself at fault. The only safe comparative rating for all lights is one based on a satisfactory illumination of a certain area—not on the total amount of light radiated.

A GARDEN SUBSTATION.

A troublesome problem of securing a proper location for a substation has been solved in a most ingenious way by a London electrical company. The Westminster Electric Supply Corporation found it necessary to erect a substation within a certain locality, in order that this district might be given a satisfactory service; but an available site seemed at first unobtainable. There was, however, a lot, belonging to the Duke of Westminster, which was used as a private garden. The owner refused to sell the lot except on the condition that a garden should form part of the building scheme. The condition was accepted by the company and met in the following ingenious way: the site was excavated, and a one-story substation placed in the basement. The roof of this substation, which is some eight feet above the street, is flat, and is laid out as a formal Italian garden. Seats are arranged at the sides; an avenue of trees, planted in tubs, stretches down the centre; a fountain plays at one part, and flower boxes are distributed at various points—the whole forming a beautiful garden.

The building itself, while possibly not just what would be selected for a substation, is still adapted admirably to the requirements. By digging the basement deep enough, a room of sufficient height has been obtained. Arched windows above the street level give light, and a ventilating system maintains a supply of fresh air and controls the temperature of the station. From the outside there is no suggestion whatever that the

structure is anything more than a raised garden. It is a decided ornament to the street, and in no way detracts from the latter as a place of residence, as might a building constructed for use as a substation only, even though of handsome appearance. Possibly some similar method might be found advantageous for certain of our larger towns, where the necessities of the public service corporations frequently cause them to turn envious eyes on little public parks, which, to the citizens, have a value far beyond what they would bring in the market.

THE GROWTH OF THE ELECTRIC LIGHT AND POWER INDUSTRY.

An advance outline of a special report on central electric light and power stations has been sent out by the Bureau of the Census, Washington, D. C. This report covers the United States during the year 1902, and hence does not represent the condition at the present time. The report is chiefly of historical value, yet it gives some intimation of the importance of the industry at the present day. References to the marvelous development of the electrical industries have become almost trite, yet one can not read over a report of this kind without being impressed again with the extraordinary growth which has taken place. This industry, at the time of the report, represented an investment of nearly $750,000,000, which was the result of less than twenty-five years' development. In 1881 eight electric lighting stations were put in operation. Five years later the number of new stations had risen to 100. Six years later the number was 247. In 1898, 277 new stations were started. After this the number of new stations has declined, because practically all the important cities and towns have been supplied, and because the modern station is far larger than the station of ten years ago and supplies a correspondingly larger district.

In the year in which the census was taken there were 3,620 central electric stations in operation, representing a cost of construction and equipment of over $500,000,000. These figures do not tell the whole story, for to supply the apparatus for this enormous investment, large electrical manufacturing establishments were created, whose welfare depended upon the growth and prosperity of the electric lighting stations.

The amount of business done by the companies is in keeping with the capital invested. The income from the sale of current alone was over $84,000,000. They employed about 30,000 officers and laborers, who were paid over $20,000,000 in wages.

The physical equipment is rated at 1,800,000 horse-power, about one-quarter of this being represented by water-wheels, and the remaining three-quarters by steam engines. There were in service about 12,500 dynamos of all kinds. One hundred and twenty-five thousand miles of wire had been erected or laid under ground. Four hundred and nineteen thousand arc lamps and 18,000,000 incandescent lamps were in service.

The stations had an output during the year of 2,500,000,000 kilowatt-hours, corresponding to 3,300,000,000 horse-power-hours. The average output per day was nearly 13,000,000 horse-power-hours, an amount of work which is approximately equivalent to what could be done if every man in the country spent the day turning a crank.

ALTERNATING-CURRENT SYSTEM ADOPTED FOR THE NEW YORK, NEW HAVEN & HARTFORD RAILROAD.

The announcement made last week, that the New York, New Haven & Hartford Railroad Company had adopted the alternating-current system for its suburban lines running into New York city, marks an important phase in electric railway development. A commission of engineers, on behalf of this company, investigated the various systems available for the road, and finally decided that, in view of present tendencies, the alternating system promised best for its particular conditions. A contract was therefore entered into with the Westinghouse Electric and Manufacturing Company for twenty-five locomotives equipped with the company's new system. This will be the first application of alternating-current railway motors on a large scale. It is one which will test thoroughly the capabilities of the system.

It will be remembered that the New York, New Haven & Hartford Railroad Company enters New York city over the tracks of the New York Central & Hudson River Railroad, which company has adopted the direct-current system for a zone reaching some thirty odd miles out from its terminus. Certain local conditions made it essential that the old method of hauling trains out of the city by means of steam locomotives be abandoned, and as the only system which had been thoroughly tried at the time when a decision for a new motive power was necessary was the direct current, the New York Central very properly decided in its favor. This was only three years ago, but, due to the progress made in electric railway apparatus during this time, the New Haven road, which will use the same tracks, has adopted an entirely different system. The decision in favor of the alternating-current motor was possible because this motor can be operated over a direct-current line. Had the New York Central adopted an alternating-current system, the New York, New Haven & Hartford would have been forced to follow suit.

The operation, side by side, of these two types of locomotives will offer an extraordinary opportunity for studying their comparative performance, and much information of the greatest value will doubtless be obtained; but it does not follow that a demonstrated superiority of one over the other would prove that the former is better than the latter for all conditions. The New York Central locomotives are of a very special type, which will be used here for the first time. The New Haven locomotives, while not as special, since they will be equipped with motors similar to those used elsewhere, are, comparatively speaking, new machines, and can not be presumed to be in a final form. No electrical engineer doubts that both systems will perform the work for which they are intended satisfactorily, but he should be very careful in drawing any broad deductions. Further, the conditions of approach to New York are special, not as regards New York as compared with other cities, but as regards this section of the two roads entering New York. It does not necessarily follow that because these locomotives may haul their trains satisfactorily that either of the two systems could be applied with financial success throughout the entire road. On the other hand, as regards the entrance of railroads into

cities, the experience of New York will be of the greatest value. Entrances into some other large cities are also made through tunnels, and where this is the case, we may expect soon to see the steam locomotives displaced by electrics. This has already been done on the Baltimore & Ohio Railroad, at Baltimore, and the electric system has been adopted by the Pennsylvania Railroad for its New York terminus. Where a road gains the centre of the city over an elevated structure, the steam locomotive will probably persist for a longer time, but even there it is doomed and the road will be forced to follow the example of the city elevated roads.

The alternating-current system bases its claims for recognition on several features. The most important are the doing away with rotary converter substations, and the enormous reduction in the amount of copper required for transmitting the current. These are the weak points of the direct-current system, and were, in fact, the objections which limited its application except in a few cases to relatively short lines. The alternating-current motor is merely a machine which has been developed in order that we may do away with these obstacles in the way of electric railway extension.

LOCAL SECTIONS OF ENGINEERING SOCIETIES.

Following the example set by the American Institute of Electrical Engineers, the American Society of Civil Engineers is considering the advisability of establishing local sections in various cities, in order to bring together more frequently the members of the society residing at these points. Such local sections undoubtedly have great value, since they increase the interest of distant members in the society, increase its membership—and thereby its strength—and give an opportunity for the exchange of ideas.

On the other hand, there are some disadvantages, and, in certain quarters, hope has been expressed that the Civil Engineers would not go on with the idea. It was said that local sections tend to make a society more exclusive and narrower, and that no benefits will be gained which could not be obtained by membership in the general engineering societies which already exist at the most of our larger cities. There is some force in this criticism. It is unfortunately true that the members of one engineering society are apt to consider those who belong to a sister society as aliens. There has been a lack of cooperation. This condition has been remedied, to some extent, by the cooperation of three of the four important national societies in the construction of a common building, but a better understanding is desirable. Could not the advantages of local sections, without their drawbacks, be obtained by cooperation with the local society? There might be a regular meeting, say once a week, at which the different professions represented could take turns in discussing papers which had been presented before the national societies. The work of the local society need not be interfered with, but its recognition of the secondary meetings would probably encourage the attendance of mechanical and civil engineers at the reading of purely electrical papers, and *vice versa*. Such an outcome would be of the greatest value. It would bring together the different bodies—locally, at least; keep the members of one society informed as to the work of the other, and be helpful in many ways. We are apt to think of the different societies as representing entirely distinct professions. This is not strictly true, since they are all specialized branches of the one great profession of engineering and the broader the grasp which one has of the whole, the better is he fitted for his narrow work.

THE NEW MAGIC.

At the meeting of the British Association for the Advancement of Science, at Johannesburg, in the latter part of August last, a public lecture was delivered by Professor W. E. Ayrton, one of the distinguished founders of the profession of electrical engineering.

Professor Ayrton's theme was the distribution of power by means of electrical currents, as applied particularly to South African conditions. He introduced his subject, however, with a brief sketch of the early attempts to apply electrical power usefully. It was at the Paris Exposition in 1881 that modern electrical engineering was born, and shortly afterward *Punch*, of London, published a cartoon exhibiting the young infant thriving, and imbibing liquid nourishment from a storage cell, the title of the cartoon being "What Will He Grow To?" We are still accustomed to say, when we wish to give our imaginations full play: "what will he grow to?" Professor Ayrton, on the other hand, says: "what *has* he grown to? Aladdin's ring and Aladdin's lamp—whose slaves brought a fortune to him, and a fainting fit to his mother—were but poor magic makers compared with the ring evolved by Gramme and that boy Paccinotti—compared with the lamp constructed by those veterans, Edison and Swan. In the 'Arabian Nights' it is stated that Aladdin's would-be uncle, the noted and learned African magician, knew that that within the wonderful lamp was not oil, and that he anticipated, by many centuries, the Johannesburg municipality, which, to reconcile the inhabitants to having the electric pressure in their houses raised from 110 to 230 volts, offer—like that other African magician—to give 'new lamps for old.' It is also described how the lamp enabled Aladdin to carry off the Princess Badroulboudour, and the wicked uncle to transport the palace. But electric traction has carried off whole neighborhoods out of cities into suburbs, and, by transporting hundreds of thousands daily, has helped to solve the problem of housing the working class; while electric distribution of power has discovered, not caves of buried jewels, but waterfalls of ever-flowing wealth."

The accomplishments of modern engineering are as wonderful as the tales of the magicians of old; the greatest difference lies in the fact that to-day we measure time more accurately, and acknowledge that whatever we get must be paid for. Doubtless, to the barbarian, who sees only the results, the triumphs of every-day engineering far surpass those of the most wonderful fairy story. That they do not seem so to us is because we are all of us magicians more or less.

THE ELECTRICAL NATURE OF MATTER AND RADIOACTIVITY.

BY HARRY C. JONES.

CHAPTER V.

The X-Rays.

In 1896 a paper appeared by Rœntgen, then of Würzburg, now of Munich, "On a New Kind of Radiation." It was announced that when an electric discharge is passed through a Crookes or Lenard tube, which is nothing but a high-vacuum tube, there is given off from the tube a kind of radiation which was unknown up to that time, and which had most remarkable properties. Among these was the property of *great penetrability*. The radiation passed through objects which were entirely opaque to light, and affected a photographic plate. When a photographic plate was covered with perfectly black paper, or placed in a black wooden box, through which no light could pass, the plate was still affected by the newly discovered radiation. Indeed, it was this fact that led to the discovery of the radiation by Rœntgen.

It was found that the radiation would pass through a great number of objects that were entirely opaque to light. Thus, comparatively thick sheets of some of the metals, such as aluminum, were quite transparent to the newly discovered radiation. It had the power of passing through metals in general, but the heavy metals, such as lead, platinum, and the like, were much more opaque to the radiation than the lighter metals. It was soon found that the bones of the body are far more opaque to the radiation than the flesh, and, therefore, photographs of the living skeleton could be obtained, which lead to a large amount of dilettanteism. It was announced that the radiation could not be refracted, nor polarized. When passed through a gas it rendered the gas a conductor, or, as we have seen, ionized the gas, in part.

Of course, these were at once recognized to be very remarkable properties; many of them entirely different from the properties of any known form of radiation. In some respects it resembled light, but in most of its properties differed fundamentally from it.

It is but natural that such a discovery should have awakened the broadest and deepest interest on the part of men of science, the world over, almost regardless of the branch of natural science to which they were devoting their energy. The first question that would naturally be asked was, *what is this newly discovered kind of radiation?* In answering this question the method of producing the radiation must be carefully taken into consideration.

NATURE OF THE X-RAY.

It will be seen that the X-ray is produced in the ordinary cathode discharge tube, and this alone would serve to connect this portion of these papers with what has gone before. We have already studied the cathode discharge, and the velocity and nature of the cathode particle. We now see that a remarkable kind of radiation is given off from the cathode tube.

Careful study showed a very close connection between the cathode discharge and the production of the radiation. It was found that the X-rays were produced where the cathode rays strike upon a solid body, such as the glass walls of the low-pressure tube. The cathode rays are thus vitally connected with the production of the X-rays.

Several theories have been advanced to account for the nature of the new radiation. While in a few respects it resembled light, in most of its properties it differed fundamentally from light. Light is a *transverse* vibration of the ether, the X-ray might be a *longitudinal* vibration in the ether, and this was the theory that was proposed by Rœntgen to account for the radiation that he had discovered. As facts accumulated this theory was found to be insufficient. Indeed, it never acquired any prominence, or received any very serious support. It remained for Sir George Stokes to propose a theory for the nature of the X-ray that would prove to be satisfactory, and account for the facts then known, as well as for those subsequently to be discovered.

The X-ray is not a succession of waves in the ether, like light, but a *series of pulses in the ether, sent out at irregular intervals.* This was in accord with their mode of formation, and accounted for their properties. They are produced when the cathode particles in a cathode discharge fall upon the glass walls of the confining vessel. These particles rain down upon the walls of the tube at irregular intervals, and if they set up any vibration in the ether, it would be expected that it would be irregular in character.

Further, matter would be supposed to be far *more transparent* to such a set of irregular pulses, than to a definite, regular set of vibrations in the ether, such as corresponds to a wave of light. To say that an object is transparent to any given form of radiation, means that it is not thrown into vibration by the radiation when the radiation falls upon the object. On the other hand, to say that an object is opaque to a vibration, means that it is thrown into vibration by the radiation. Glass is transparent to light because it is not thrown into vibration by the light. A thin sheet of metal is opaque to light because the light waves falling upon it produce vibrations within the metal.

This is just what we would expect, since, if the radiation sets up vibrations in the object upon which it impinges, its energy is expended in setting up the vibrations, and the radiation as such is lost.

The penetrating power of the X-ray is thus explained by the Stokes' theory as to its nature.

Similarly, this theory accounts satisfactorily for the other well-recognized properties of the X-ray, and is now generally accepted.

THE BECQUEREL RAY.

The X-ray is produced, as we have seen, where the cathode ray falls upon the wall of the glass tube. It will be remembered, from an earlier paper, that where the cathode ray falls upon the wall of the tube a phosphorescent spot is produced on the glass. For a time it was supposed that this phosphorescence is in some way intimately connected with the production of the X-ray. Although it has subsequently been shown that this is not the case, and that X-rays are produced better, when the cathode ray falls upon a metal plate which does not become fluorescent, than when it falls upon glass which does. Yet this original idea, although erroneous, led to highly important discoveries.

With the idea that fluorescence and X-rays are vitally connected, men of science began to examine bodies that were naturally fluorescent, to see whether they gave off any form of radiation analogous to the X-ray, or any unknown form of radiation, whatsoever.

The first observation of importance in this field was that made in 1896 by Niewenglowski, very shortly after the announcement by Rœntgen of his discovery. Niewenglowski exposed calcium sulphide to the sunlight, then wrapped it in black paper to cut off the light, and exposed a photographic plate to it. If any radiation was given off that could penetrate black paper, it might act on the photographic plate. Rays were given off from the calcium sulphide that had been thus treated which passed through the black paper that was opaque to light, and af-

fected the photographic plate. If these radiations were light they were different from ordinary light in having greater penetrating power.

Similar results were recorded a little later by Becquerel and others. These effects are probably due to the emission of light of very short wave-length, which has the property of penetrating certain objects that are opaque to ordinary light.

This substance is not radioactive in the sense in which we use that term to-day. It remained for Henri Becquerel to *discover the first naturally radioactive substance.* Guided by the erroneous idea that there was some connection between the fluorescence produced on the glass by the cathode ray, and the production of the X-ray by cathode rays, Becquerel began examining fluorescent substances to see if any of them gave off a radiation at all analogous to the X-ray. He chose among these substances the salts of uranium, and found that these compounds produced an impression on a photographic plate wrapped in black paper to cut off all ordinary light. The radiations given off by the salts of uranium could pass through thin plates of metal and still affect the photographic plate.

Becquerel supposed at first that it was necessary to expose the fluorescent salts of uranium to sunlight, in order to obtain from them the radiation referred to above. He found later that this radiation was given off even when the uranium compound had not previously been exposed to light.

Becquerel tested the question, as to whether the effect on the photographic plate was due to any volatile substance given off from the uranium salts. This was especially desirable in the light of the recent work of Russell, on substances that would produce a fogging of photographic plates, even when the plate was not directly, but only indirectly exposed to the substances in question. To test this point the photographic plate, wrapped in black paper, was screened from the uranium compound, by a thin plate of glass. The glass would have cut off any volatile substance given off from the compound of uranium. The photographic plate was still affected, which showed that the effect was not due to any volatile substance coming from the salt of uranium.

Becquerel found that *all the salts of uranium* would produce the effect, both those that are phosphorescent, and those, like the uranous salts, that are not. The effect was thus shown not to be directly connected in any way with phosphorescence. The effect produced by the non-phosphorescent compounds was just as great as that produced by those that are phosphorescent, provided that they were taken in quantities that contained the same amount of uranium. It was soon shown that metallic uranium itself was not only active, but more active than any of its compounds.

The radiations given off by uranium either in the elementary state or in its compounds, have nothing to do with its previous exposure to light. When the metal or its compounds are kept for a long time in the dark, the intensity of the radiation is undiminished. It is thus obvious that the energy given out by the uranium radiations is not derived from sunlight.

Further, the intensity of the radiation given out by uranium is not diminished in four or five years—the longest time over which observations have thus far been extended. In these experiments the uranium salts were preserved in lead boxes, which are especially opaque to such radiations as we are now considering, and the intensity of the radiations measured photographically from time to time without removing the uranium compound from the lead box. In this way the uranium salt was never exposed to radiations from external sources, and yet it continued to give off radiations with undiminished intensity. The energy of the uranium radiation is thus intrinsic in the uranium, and does not come from any external source.

This property of substances to emit radiations naturally like uranium, without any external cause, is known as *radioactivity,* and such substances are *radioactive.* There are a number of such instances, as we shall see.

PROPERTIES OF THE BECQUEREL RAYS.

It was early recognized that the uranium radiations, like the Rœntgen rays, have many remarkable properties. As we shall see, they have some properties in common, while others are quite different.

The uranium radiations, like the X-ray, have the property of ionizing gases through which they pass. This is shown by the fact that they discharge charged bodies surrounded by the gases through which these radiations pass. The gases are ionized by the radiations, and then conduct the charges away from the charged bodies with which they come in contact.

In this respect, as well as in their power to affect a photographic plate, the uranium rays act like the X-ray, but they are very much feebler. This applies both to their action on a photographic plate, and their power to ionize a gas. From these facts alone it might be concluded that the Becquerel ray is nothing but a very feeble form of the X-ray.

The rays from uranium can not be reflected, refracted nor polarized, and thus again resemble the X-ray. We shall learn, when we come to study the properties of the uranium radiation in detail, that it is not a simple radiation; but is complex, consisting of rays that have considerable penetrating power and can be deviated by a magnet; also of rays that have great penetrating power and are not deviated by a magnetic field; and, in addition, contains a third kind of rays that have only slight penetrating power, and are easily stopped by thin sheets of matter; but more of this later, when the properties of the several kinds of radiations are more closely studied.

THE THORIUM RADIATION.

After Becquerel had shown that one natural substance is radioactive, or has the power of giving out radiations that can pass through considerable thicknesses of matter opaque to light, as well as ionize a gas and affect a photographic plate; a search was made for other natural substances having the same properties. The first one discovered was the comparatively rare element thorium, which plays such an important part in the Welsbach mantle. Schmidt, in 1898, found that thorium, whether elementary or in combination, had properties analogous to those possessed by uranium. It gave out radiations that acted, if only feebly, upon the photographic plate. It ionized a gas, like the radiations from uranium, but possessed properties that distinguished it sharply from the uranium radiation. There is given off from the thorium something that is blown about by the slightest currents of air, and which in some respects resembles a gas. This was discovered by Rutherford and termed by him an *emanation.* This emanation, we shall learn, has remarkable properties.

Monument to Gramme.

A monument to Zénobe Theophile Gramme will be unveiled at Liege, Belgium, on October 7. Gramme was born in Belgium on April 6, 1826, and was by trade a cabinet maker. He studied physics in Paris and Berlin, and in 1865 equipped a laboratory in Paris for his own use. He patented a number of electrical devices, one being an alternating-current machine which he patented in 1867. In 1869 he constructed a magneto dynamo, and in 1872 he patented the type of armature known as the Gramme ring.

THE CHEMISTRY OF ELECTRO-CHEMISTRY.[1]

BY WILDER D. BANCROFT.

The development of electrochemistry has not been such as to lay great stress on the parallelism between electrolytic action and ordinary chemical action except for the case of the electrochemical or voltaic series. It is to the electric furnace that we really owe a new point of view. In all cases where the current is used only for heating we are, of course, dealing with the chemistry of a higher temperature pure and simple. The part played by the current is that of a glorified Bunsen burner. With this in mind we naturally ask ourselves what part is to be assigned to the current in electrolysis and how far we have to deal with any specific effect. We will define the substances carried to the anode and cathode by the current as the anions and the cations respectively. This is Faraday's definition and involves no assumptions. What the ions are in any particular case is a question to be decided by chemical analysis, using some modification of Hittorf's method. In the case of electrolytic action it is only necessary to postulate that the current tends to set free the anions at the anode and the cations at the cathode. What happens over and above that is a question of chemistry, depending on the reaction velocity and equilibrium relations in each particular case. By citing a few instances, some of them familiar to every one, I hope to show that a closer study of the chemistry of electrochemistry will be of benefit both to chemistry and to electrochemistry.

Let us consider first the reactions at the cathode. If we pass a current through a slightly acidified solution of copper sulphate we get the precipitation of metallic copper. This is merely the normal action of the current setting free the cation, copper, at the cathode. If we acidify the solution still further, adding sulphuric acid in one case and nitric acid in another, we find that a given amount of nitric acid will prevent the precipitation of copper, while much more sulphuric acid must be added to cause the same effect. The reason of this is clear when we consider the chemistry involved. Nitric acid attacks copper readily and sulphuric acid does not. While this is perfectly obvious when stated in this way, it has not been obvious enough in the past to induce any one to test quantitatively the relation between the decreased current efficiency in a nitric acid solution and the rate of corrosion by that particular solution. We know that the current efficiency increases with current density,[1] which is just what we should expect if the chemical action remains constant; but more than that we do not know.

While it is only under special circumstances that it becomes impossible to precipitate copper from an aqueous solution, it is on the other hand very difficult to precipitate sodium. The rapid chemical action of sodium on water is the cause of the difficulty. If we could find a solvent which did not react with sodium and in which a sodium salt would dissolve forming a conducting solution, we should be able to precipitate sodium without difficulty. No such solvent has yet been found for sodium salts, but acetone, alcohol, pyridine, etc., are said to satisfy the condition so far as lithium salts are concerned. If we electrolyze a solution of lithium chloride in acetone, using an iron cathode, we get a bright metallic precipitate which reacts readily with water, forming lithium hydroxide. For demonstration purposes this is entirely satisfactory; but no one has ever plated lithium to any thickness, and some experiments made in my laboratory lead me to suspect that we are really dealing with a lithium-iron alloy. By working with fused salts or mixtures of fused salts we can precipitate the metals which decompose water, provided we adjust the temperature so that the precipitated metal does not react with the bath. Thus we can precipitate sodium from fused caustic soda at temperatures just above 300 degrees, but if the temperature is raised too high the sodium reacts with the bath and the yield falls off. We have a similar experience in the electrolytic precipitation of aluminum, though with different temperature limits. In the electrolysis of fused calcium or barium chloride there is a loss due to the formation of CaCl or BaCl.

Coming back to the case of a sodium salt in aqueous solution, it is easy to see that we could precipitate sodium if we could decrease the rate at which it reacts with water. Owing to the decrease of the concentration and of the vapor pressure of the sodium, sodium amalgam reacts with water much less rapidly than does metallic sodium. It should therefore be possible to form sodium amalgam electrolytically by using a mercury cathode, and this is the case. The yield depends on the relative rates of formation and decomposition of the amalgam. Sodium amalgam is less dense than mercury. If the mercury cathode is below the solution, a crust of sodium-rich amalgam forms at the surface, the rate of decomposition increases and the yield decreases. If the mercury cathode is placed above the solution by means of a porous cup or other device, the solution is in contact with a sodium-poor amalgam, the rate of decomposition is low and the yield is relatively high.[1] If we increase in any other way the rate at which sodium amalgam reacts with water we shall decrease the current efficiency. J. W. Walker[2] has shown that the presence of iron or nickel in mercury prevents the formation of sodium amalgam because the rate of decomposition becomes so high.

At low concentration sodium amalgam is a liquid alloy, but the same general relations will hold in all cases, and it is easy to conceive of a case in which a solid alloy would have such a high rate of decomposition that it could not be formed at all if the current density or rate of formation were low and would decompose practically as fast as formed if the current density were high. This has been realized experimentally by Haber,[3] using a caustic soda solution and a lead cathode. With a moderate current density hydrogen is set free at the cathode and there are no abnormal phenomena. With a very high current density, say five amperes per square centimetre, a sodium-lead alloy is formed which breaks down practically at once, scattering pulverulent lead through the solution in a black cloud. This same black cloud is obtained chemically if we drop into water a sodium-lead alloy rich in sodium. This disintegration of the cathode through formation and decomposition of an alloy accounts for the slow blackening of platinum cathodes when a high current density is used. With platinum we have usually only a surface formation of platinum black and not a violent disintegration, as with lead; but this is probably due chiefly to the difference in the concentration of the alloy formed. The important thing to be noticed is that the phenomenon became clear only when attacked both from the chemical and the electrochemical sides.

Coming back to the case of copper sulphate and starting with a neutral solution, we find cuprous oxide mixed with the copper at the cathode. This is ap-

[1] A paper presented at the eighth general meeting of the American Electrochemical Society, held at Bethlehem, Pa., September 18, 19 and 20, 1905.

[1] Beadle, *Electrochemist*, i. 168 (1901)

[1] Shepherd, *Jour. Phys. Chem.*, vii, 29 (1903).

[2] Trans. Amer. Electrochem. Soc., iii, 185 (1903).

[3] Ibid, ii, 189 (1902).

parently due to hydrolysis, according to the equation

$$Cu_2SO_4 + H_2O = Cu_2O + H_2SO_4.$$

The proof rests on the chemical evidence of the formation of cuprous sulphate in acid solution by heating copper sulphate with copper, the reversible reaction being[1]

$$CuSO_4 + Cu = Cu_2SO_4.$$

In neutral solutions cuprous sulphate hydrolyzes, precipitating cuprous oxide. It has also been shown that no cuprous oxide is formed electrolytically if the solution is more than slightly acid.[2] Here again the chemical and the electrochemical investigations have gone hand in hand, to the great advantage of both. It is quite possible that we should modify our views somewhat if our chemical knowledge of the subject were more accurate. We know that basic sulphates tend to precipitate when a neutral copper sulphate solution is boiled, but we do not know whether we have in the solution of the basic salt a cation containing both copper and oxygen. Such a hypothesis seems not at all improbable when we come to solutions of the sulphates of the rare earths, and there is no question about it in the case of uranyl chloride.[3]

If we electrolyze a solution of copper sulphate plus zinc sulphate we get a precipitation of copper. The reason why no zinc can precipitate as such becomes clear when we dip a rod of zinc into a copper sulphate solution. The copper precipitates and some zinc dissolves. When no other disturbing factors occur, we find that the more rapidly one metal precipitates another from solution, the less readily will that metal be precipitated electrolytically from a solution containing the two metals. Thus more care has to be taken in separating silver from copper than in separating copper from zinc or cadmium. There are some apparent exceptions to this, but a study of the chemistry involved clears up matters. In sulphate, nitrate or acetate solutions, massive aluminum or massive nickel will not precipitate copper. Under certain conditions iron will not precipitate copper. In all of these solutions copper precipitates electrolytically before these other metals. If we examine into the matter we find that while nickel, for instance, does not precipitate copper, neither does copper precipitate nickel. We are therefore not dealing with a reversible reaction, and the presumption is that the conditions are not as stated. As a matter of fact we find that the aluminum, the nickel and the iron are covered with a surface film, so that the metals do not come in direct contact with the copper sulphate solution at all. With the iron a mere scratch suffices to break the film and to cause the precipitation of copper.

In a previous paper I have shown that the physical qualities of electrolytically precipitated metals become intelligible when we consider the chemistry involved.[1] In this way we get, at any rate, a tentative theory of electroplating.

Quite another set of problems comes up when we consider the electrolytic precipitation of alloys. We know that zinc and copper form six series of solid solutions at certain temperatures, and it is not at all clear how it is that copper can be precipitated pure from a solution containing zinc. The difficulty here is that we know nothing as yet about the chemical side of the problem, about the equilibrium between brass and the sulphate solutions. What has seemed to be one of the simplest problems in electrolytic analysis, the separation of copper from zinc, is really a very puzzling one theoretically, because we know so little about the chemistry of the matter. It is not possible to discuss the results of Mylius and Fromm[2] and of Senderens[3] on the chemical precipitation of alloys, because our knowledge of alloys is still very rudimentary.

The electrolysis of a solution of the sulphates of zinc and copper has been discussed as a separation of copper from zinc. We may also consider the electrolysis of an acidified copper sulphate solution as a separation of copper from hydrogen. Since the copper precipitates before the hydrogen we should expect this to mean that hydrogen precipitates copper from solution. At first sight this seems not to be true. One can bubble hydrogen through a copper sulphate solution forever without precipitating any copper. We are not doing our chemical experiment under the same conditions that we used in the electrochemical experiment. In the latter the copper was precipitated at an electrode. If we place a piece of metal, preferably platinum, in a copper sulphate solution and pass in hydrogen gas we shall get a reduction by the hydrogen to metallic copper.[4] It is this apparent inertness of hydrogen gas which has led to the conception of nascent hydrogen. In all cases where we have effects due to so-called nascent hydrogen, we have a metal present and the effect is either due to the metal or can be duplicated by hydrogen gas in contact with a metal. This will come up again when we consider the effects due to the nature of the cathode. There is one point, however, which is still obscure, apparently owing to our ignorance of the chemistry involved. It requires a higher voltage to set hydrogen free at certain electrodes than at others.[1] Zinc is a metal giving a particularly high "excess voltage," as it is called. It is owing to this "excess voltage" that it is comparatively easy to precipitate zinc or cadmium from a solution which is perceptibly acid. This may be connected with the fact that pure zinc does not dissolve readily in acid solutions; but beyond that our knowledge does not go as yet. It should be kept in mind, however, that the inertness of zinc to acid, or of hydrogen to copper sulphate, is different in kind from the inertness of nickel or aluminum to copper sulphate. In the first two cases contact with platinum causes the reaction to go normally. In the last two cases contact with platinum produces no effect.

We have already seen that under certain circumstances the cathode may be distinguished mechanically. If the cation reacts with the solution to form a new solution which attacks the cathode, the cathode may be dissolved. If we electrolyze a solution of a sodium salt between platinum electrodes, using a diaphragm, we shall have caustic soda and hydrogen formed at the cathode. If we repeat this experiment using a hot solution between zinc electrodes the caustic soda will attack the zinc, forming sodium zincate. While this particular case has not been studied, we have a similar one in the electrolysis of ammonium nitrate solutions with an iron cathode.[2] The iron dissolves in the ammoniacal ammonium nitrate solution. The same result can be obtained chemically by placing iron in ammonium nitrate solution to which ammonia has been added. The phenomenon is purely a chemical one and is not due to a mysterious action of the electric current.

If we electrolyze the salt of a metal which can have a varying valency we may meet special difficulties, but they all become intelligible when we consider the

[1] **Foerster and Seidel**, *Zeit. Anorg. Chem.*, xiv, 106 (1897). Cf. Richards, Collins and Heimrod, *Zeit. Phys. Chem.*, xxxii, 321 (1900).

[2] **Foerster and Coffetti**, *Zeit. Elektrochemie*, x, 736 (1904).

[3] **Hittorf**, *Poggendorff's Ann.*, cvi, 393 (1859).

[1] *Jour. Phys. Chem.*, ix, 277 (1904).

[2] *Ber. Chem. Ges.*, Berlin, xxvii, 630 (1894).

[3] *Bull. Soc. Chim.*, Paris, xv, 1241 (1894); xvii, 271 (1897).

[4] **Neumann**, *Zeit. Phys. Chem.*, xiv, 193 (1894).

[1] **Jaspari**, *Zeit. Phys. Chem.*, xxx, 89 (1889).

[2] **Kaufman**, *Zeit. Elektrochemie*, vii, 733 (1901).

chemistry of the solutions. If we start with a solution of ferric sulphate or chloride we do not get metallic iron precipitated, because iron and ferric sulphate or chloride reacts to form the ferrous salt. Since the equilibrium is reached only when practically all the ferric salt has disappeared, it is necessary to reduce the ferric salt practically completely to ferrous salt before metallic iron can be obtained. Owing to the relative instability of chromous sulphate, metallic chromium can be obtained while there is still a great deal of chromic sulphate in the solution.[1] Cuprous sulphate is so unstable at ordinary temperatures that it need not be considered except in so far as we have to deal with its decomposition products in neutral solutions. At 100 degrees a measurable amount of cupric sulphate must be reduced before metallic copper will precipitate. This amount will be greater the more thoroughly the solution is stirred; in other words, the more nearly the film of solution at the surface of the cathode corresponds in composition to the solution as a whole. When a solution contains an "ous" and an "ic" salt in equilibrium with the metal, the amount of metal precipitated per 96,600 coulombs will lie between that of the two equivalent weights if no other reaction takes place. If the concentration be kept constant and if the current density be infinitely low, the weight of metal precipitated will depend on the relative amounts of the two modifications of the metal as ion. If we postulate Faraday's law we can determine the relative concentrations of the "ous" and the "ic" ions. Since cuprous sulphate is formed from copper and cupric sulphate with absorption of heat, it will be the more stable form at the higher temperature and the apparent equivalent weight will rise or the apparent valency decrease. This can be put in a more general form. Most salts are formed with evolution of heat and therefore tend to dissociate the higher the temperature. In general, therefore, the apparent valency of a metal will be lower the higher the temperature. At a temperature and pressure at which the silver halides decompose into silver free halogen, the valency of silver with respect to the halogen becomes zero. The same is true for mercury with respect to oxygen at the temperatures and pressures at which oxide of mercury dissociates. Reference has already been made to the existence of CaCl and BaCl at high temperatures.

For zero current density the electrochemical and the chemical equilibria must be the same for all reversible reactions. For any finite current density we have to consider reaction velocities. Massive iron does not react rapidly with a ferric salt. If the electrochemical reaction be made to take place faster than the chemical one, there may easily be a displacement of equilibrium. This applies not only to the different stages in the reduction of a metallic salt, but to the evolution of hydrogen. The percentage reduction will decrease with any change which accelerates the evolution of hydrogen. Here we have to consider both the nature and the physical state of the electrode. A depolarizer which reacts slowly will not give the same result as one that reacts rapidly, quite apart from any question of potential. In general, we can say that we shall diverge farther from the chemical equilibrium the higher the current density. This is merely another way of saying that the so-called primary reaction is favored by low-current density.

We will now consider some of the reactions at the anode. The simplest case is that of a practically insoluble anode, such as graphite in a hydriodic acid solution. The normal effect of the current by definition is to set free the anion, as iodine, at the anode. This actually happens. If we electrolyze a solution containing chloride and iodide we have iodine set free. The reason that no chlorine is set free is because chlorine gas precipitates iodine from a solution of an iodide. To this extent the reaction at the anode is the exact analogue of the reaction at the cathode. If we consider the electrolysis of hydrochloric acid between graphite electrodes we find some complications at the anode. The normal product of electrolysis is chlorine, and chlorine is the main product, under certain circumstances practically the whole product. The chlorine can and does react with the water according to the equation

$$Cl_2 + H_2O = HCl + HClO.$$

The hypochlorous acid thus formed may react in two ways,

$$3HClO = HClO_3 + 2HCl,$$

and

$$2HClO = 2HCl + O_2.$$

We will confine ourselves to the second of these reactions because it introduces another gas, oxygen. We know that this reaction takes place, but we do not know definitely whether it is or is not reversible. No one has ever made hypochlorite by the action of oxygen or sodium chloride, and this is an argument against the reaction being reversible. On the other hand Smale[1] found 0.878 volt for the electromotive force of the hydrogen-oxygen gas cell in normal hydrochloric acid; 1.074 volts for the hydrogen-oxygen gas cell in normal sulphuric acid, and 1.360 volts for the hydrogen-chlorine gas cell in normal hydrochloric acid. It is difficult to account for the low value of 0.878 volt unless one assumes, as Smale did, that the oxygen has reacted with the hydrochloric acid, setting free some chlorine. This is an argument in favor of the reaction being reversible.

If we assume that the reaction is irreversible, chemical equilibrium in the system, chlorine, hydrochloric acid and water will be reached only when all the chlorine has been replaced by oxygen. If we assume that the reaction is reversible, the chemical equilibrium will vary with the hydrochloric acid concentration, the gas phase containing a higher percentage of chlorine the more concentrated the hydrochloric acid is. On electrolysis we shall reach the chemical equilibrium if we use zero current density, and a different result with finite current densities. If the electrode has a catalytic action on hydrochlorous acid, the results for any given current density will come closer to the values for equilibrium than they will with an electrode which does not exert such a catalytic influence. The whole matter is complicated to a certain extent by the apparent decomposition voltage of water at 1.67 volts. While all this may appear to be hopelessly elementary, an examination of the admirable paper by Haber[2] on the electrolysis of hydrochloric acid will show that the close relation between the chemistry and the electrochemistry of the problem has not been fully understood even in the very recent past.

As has been said, the normal effect of the current on a chloride solution is to set free chlorine at the anode. If any reaction can take place more readily than the evolution of chlorine, chlorine will not be set free. If we have a zinc anode the zinc and chlorine react, forming zinc chloride, which is soluble. If we have a silver anode the silver and chlorine react, forming silver chloride, which is insoluble. Both these reactions can be duplicated chemically. If we bring caustic soda into the anode solution in any way the chlorine will react with it, forming hypochlorite as the first product. If we bubble chlorine gas into the same alkaline solution we get the same product. If we pass chlorine gas into an alkaline solution to which cobalt

[1] Carveth, *Jour. Phys. Chem.*, ix, 231 (1904).

[1] *Zeit. Phys. Chem.*, xiv, 594 (1894); xvi, 564 (1895).

[2] *Zeit. Anorg. Chem.*, xvi, 198, 329, 438 (1898).

sulphate has been added, we get an evolution of oxygen and a precipitation of a cobaltic oxide. No hypochlorite is formed until the cobalt is oxidized completely. If we add cobalt sulphate to a sodium chloride solution and electrolyze without a diaphragm we get an evolution of oxygen at the anode and the precipitation of a cobaltic oxide. No hypochlorite is formed until the whole of the cobalt is oxidized. At ordinary temperatures this is not a catalytic reaction as has been supposed, but a coupled reaction, presumably involving the formation of an intermediate compound. It is stated on good authority that at ninety degrees the cobaltic oxide acts as a true catalytic agent. If this is true we have a most interesting change between twenty degrees and ninety degrees, one that is well worth studying and one that brings out clearly the great value of studying the chemistry of electrochemistry.

In the case of a chloride solution it was possible to isolate the normal anode decomposition product, chlorine, and to study its chemical reactions directly. This is not possible with a sulphate solution because the radical SO_4 is not stable as such, or in a polymerized form, $(SO_4)n$. What is usually done is to say that this radical reacts with water, setting free oxygen according to the equation

$$2SO_4 + 2H_2O = 2H_2SO_4 + O_2.$$

This, however, is an assumption *ad hoc* and should be tested in some other way; for instance, by setting free the radical SO_4 in some purely chemical way, and showing that it does or does not react with water, setting free oxygen. This can be done by heating a solution of ammonium persulphate or of persulphuric acid. If we do this we have sulphate formed and SO_4 set free. As a matter of fact, oxygen is evolved under these circumstances.[1] If zinc or copper is placed in the solution the metal is attacked, just as it is when made anode in a sulphate solution. We thus obtain the same results by chemical methods and by electrochemical methods. It may be asked what we have gained by doing this. The justification for the point of view is the same for the sulphate electrolysis as for the chloride electrolysis, that it brings out clearly gaps in our knowledge which had hitherto been overlooked. When persulphuric acid breaks down at ordinary temperatures, the reaction proceeds in two stages, hydrogen peroxide being the intermediate decomposition product. This at once raises the question whether hydrogen peroxide is formed when a sulphate is electrolyzed. We know that hydrogen peroxide is always formed when sulphuric acid containing six[t]y to ninety per cent H_2SO_4 is electrolyzed,[1] and we know that in those solutions hydrogen peroxide decomposes less rapidly than in sulphuric acid of other concentrations. It is quite conceivable that we do not detect hydrogen peroxide in other solutions merely because the catalytic action of the electrodes causes it to decompose as fast as it forms.[2] We need a careful study of the equilibrium relations and reaction velocities in the system, sulphuric acid, water, and hydrogen peroxide. The chemical and electrochemical relations of ozone to these substances and to the decomposition voltage of 1.67 volts also call for a great deal of study.

One other point in regard to the electrolysis of sulphate solutions is worth noting, as it brings out clearly our ignorance. In Germany the oxygen evolved during the electrolysis of sulphuric acid is believed to come from the water, according to the equation

$$SO_4 + H_2O = H_2SO_4 + O.$$

In France the oxygen is supposed to come from the sulphate radical itself, according to the equations

$$SO_4 = SO_3 + O$$
$$SO_3 + H_2O = H_2SO_4.$$

So far as I know, no one has ever brought forward any proof which would enable us to decide between these two views. We know that solid ammonium or potassium persulphate breaks down into sulphate, sulphur trioxide and oxygen, which is an argument in favor of the French point of view. The formation of hydrogen peroxide from persulphuric acid falls more in line if we consider the oxygen as coming from the sulphate radical. On the other hand, the formation of persulphates seems to be an argument on the other side. Whatever the final decision may be, I wish now merely to emphasize the fact that this is a problem which has not been faced in the past, largely because we have kept our chemistry and our electrochemistry more or less apart.

The chemical duplication of the electrolysis of sulphate solutions was obtained by heating persulphate solutions. Addition of potassium cyanide or potassium iodide to copper sulphate solutions sets free cyanogen or iodine respectively. Mulliken[3] has shown that the same new ester is formed whether we electrolyze sodium malonic ester or whether we add iodine to the solution. A similar result could doubtless be obtained with halogen compounds by adding colloidal metals to the solution. I have not yet been able to think of any method by which we can duplicate chemically the setting free of nitrate as ion, but, of course, the percarbonate stands to the carbonate as the persulphate to the sulphate.

The oxidation of ferrous to ferric salts at the anode is merely the converse of the reduction of ferric to ferrous salts at the cathode, and therefore need not detain us. The chemical oxidation of cobaltous to cobaltic sulphate needs to be studied, and the catalytic effect of hydrochloric acid on the formation of persulphuric acid will probably become intelligible when studied from the chemical side. The reason that the temperature must be kept low in the electrolytic formation of persulphates, percarbonates and cobaltic sulphate, is the very simple one that these substances decompose when heated. The essential factor is the temperature at the surface of the electrode, which is not necessarily the mean temperature of the solution[1] any more than the concentration at the surface of the electrode is necessarily the same as the mean concentration. Fischer[2] has made use of the heating of a small electrode in the experiment on the so-called disintegration of a copper anode. If a copper wire be made anode in a sulphuric acid solution while a heavy current passes, the temperature at the surface of the wire will rise and cuprous sulphate will be formed, which breaks down into copper and cupric sulphate when it is hurled by bubbles of steam out into the cold solution.

We meet another type of oxidation in the precipitation of lead peroxide during the electrolysis of acidified lead nitrate solution. This oxidation can be effected chemically by adding sodium peroxide to the solution. It is probable that this is merely an addition of concentrated hydrogen peroxide. Sodium peroxide will oxidize cobalt sulphate to cobaltic oxide, and a similar reaction can be effected electrolytically.[3]

While the reaction at the anode may be the exact converse of one at the cathode, this can be so only when the reaction in question is strictly reversible. This is very often, perhaps usually, not the case. Extreme instances are to be found in the passive metals. The reaction in the silver

[1] In showing this as a lecture experiment it is advisable to add a little manganous sulphate as catalytic agent.

[1] Richarz, *Wied. Ann.*, xxiv, 183 (1885); xxxi, 912 (1887).

[2] Cf. Haber and Grinberg, *Zeit. Anorg. Chem.*, xviii, 37 (1898).

[3] *Am. Chem. Jour.*, xv, 523 (1893).

[1] Richarz and Ziegler, *Wied. Ann.*, lxiii, 261 (1897).

[2] *Zeit. Elektrochemie*, ix, 507 (1903).

[3] Coehn, *Zeit. Elektrochemie*, iv, 501 (1898).

voltameter is sufficiently different to make it necessary to separate the anode and cathode solutions. In the formation of chlorate we always pass through the intermediate stage of hypochlorite, while this substance can not be detected in the reduction of chlorate to chloride. One interesting case may occur when the reaction at one electrode is practically the converse of the one at the other electrode. If we electrolyze a mixture of ferric and ferrous salts between platinum electrodes, the ferrous salt will be oxidized to ferric salt at the anode and the ferric salt will be reduced to ferrous salt at the cathode. If the current densities and concentrations are so arranged that the oxidation and reduction efficiencies are each 100 per cent, and if the solution is kept well stirred, the total effect of the current will be zero[1] and the solution will behave like a metallic conductor. Metallic copper reacts with ferric sulphate, forming ferrous sulphate and cupric sulphate. If we electrolyze a solution of ferrous and copper sulphates, using a platinum anode, the ferrous salt will be oxidized at the anode, and the ferric salt thus formed will tend to react with the copper at the cathode, cutting down the current efficiency with respect to copper. If we substitute a copper anode for the platinum one, the ferrous salt can not be oxidized, because it is easier to take copper into solution than to oxidize a ferrous salt. Consequently there will be no falling off in the cathode current efficiency.[2] If any ferric salt is formed in any other way, it will be reduced by copper from the anode rather than by copper from the cathode.

We can now take up the formation of salts. In the chlorate process we have the mixing of the cathode and the anode products, caustic potash and chlorine. The admirable work done in Foerster's laboratory has shown that there is no direct oxidation of chloride to chlorate. The success of these investigations was due primarily to the fact that Foerster and his collaborators studied the chemical and the electrochemical phenomena simultaneously. A case of theoretical interest is the electrolytic formation of hydroxides and oxides of the heavy metals. If we electrolyze a sodium chloride and a sodium sulphate solution with copper electrodes, we get an orange precipitate in the sodium chloride solution if cold, and a red one if hot, while we get a bluish precipitate in the sulphate solution if cold, and a black one if hot. The electrochemical reaction in all four cases is the formation of a copper salt at the anode and of caustic soda at the cathode, the two products then reacting. In the sulphate solution copper sulphate is formed. Now copper sulphate reacts in the cold with dilute caustic soda to form bluish cupric hydroxide. When the solutions are hot, black cupric oxide is formed. In the sodium chloride solution, cuprous chloride is formed instead of cupric chloride. Cuprous chloride reacts with cold dilute caustic soda to form the orange-colored cuprous hydroxide, and with hot caustic soda to form red cuprous oxide. The different results in the four cases become intelligible just as soon as one considers the chemistry involved. If the same experiment is tried with nickel cathodes, the same precipitate is obtained in the four cases, but the quantity varies. There is very little difference between the two chloride solutions, but there is less precipitate in the hot sulphate solution than in the chloride solutions and there is scarcely any precipitate at all in the cold sulphate solution.[1] This fits in with what we already know as to the passivity of nickel in copper sulphate solutions. In sulphate solutions nickel becomes covered with a thin film of oxide and does not dissolve readily. In a hot solution the solvent action is greater and more nickel goes into solution to be precipitated as hydroxide by the caustic soda coming from the cathode. In chloride solutions the nickel does not become passive and very nearly the theoretical amount goes into solution.

After considering this special case of the formation of an insoluble salt we can take up the more general case. If the anion, when set free, reacts with the metal of the anode to form an insoluble salt, we shall get this salt on electrolyzing the solution, but it will be precipitated as a more or less coherent film at the anode, which may be unpleasant. If the insoluble salt can be formed away from the anode, the anode will remain bright. This happens in the electrolytic formation of the hydroxides because the insoluble salt is not precipitated until the anode and cathode solutions mix. In the Luckow patents for making insoluble salts, the solution contains two salts. The anion of one forms a soluble salt with the metal of the anode, while the anion of the second forms an insoluble salt with the metal of the anode. In making lead chromate, for instance, the salts would be sodium chlorate and sodium chromate. The object is to have the lead dissolve as chlorate and precipitate as chromate. Luckow attains this by having very little chromate relatively to sodium chlorate in the solution. It seems probable that the cell is theoretically a two-solution one without a diaphragm. If we had sodium chlorate in the anode compartment and a mixture of sodium chromate and chlorate in the cathode compartment, the formation of lead chromate would take place at the surface between the two solutions and not at the anode. If we have a single solution and a very small amount of sodium chromate, the first precipitation of lead chromate will make the concentration of sodium chromate practically zero in the immediate neighborhood of the anode. If this explanation is the correct one, vigorous stirring would be disadvantageous.

Reference has been made to the formation of an insoluble salt on the anode. This is made use of when we determine bromine or chlorine with a silver anode. The peculiarities resulting from the presence of a film on the electrode all follow from the physical and chemical characteristics of the film. In general, at the temperature of the experiment the solid salt is not a conductor of electricity. If the salt is present merely as non-conducting particles, it increases the resistance, but increases it regardless of the direction in which the current passes and regardless of the nature of the solution. This case is well illustrated by a mercury electrode covered with mercurous sulphate.[1] If the insoluble salt forms a semipermeable membrane, we shall get added effects due to the chemical and physical peculiarities of the membrane. A copper ferrocyanide membrane is nearly impermeable to copper as ion. If we start with such a membrane in a copper sulphate solution we can precipitate metallic copper upon it by electrolysis.[2] If a membrane is impermeable to sulphate as ion and permeable to hydrogen as ion, we shall get the current passing readily in one direction while it is checked in the opposite direction. This is what appears to happen in the aluminum rectifier, and we made progress in the theory of the phenomena of the rectifier only when Taylor and Inglis[3] studied the chemical as well as the electrical phenomena.

One other point calls for discussion. It has been found that electrolytic reduction takes place more readily at certain cathodes than at others, zinc, copper and tin being the best in certain cases, lead in others. It appears to be a specific action of the cathode in each case. In

[1] Oettel, Ibid. i, 91 (1894).
[2] Bell, *Jour. Phys. Chem.*, vii, 652 (1903).

[1] Le Blanc, Boltzmann's Festschrift, 183 (1904).

[1] Cohen, *Zeit. Phys. Chem.*, xxviii, 723 (1899).
[2] Ostwald, Ibid, vi, 71 (1890). Mijers, Recueil, Trav. Pays. Bas (2) xvii, 177 (1898).
[3] *Phil. Mag.* [6], v, 300 (1903).

the Boehringer patents for reducing nitrobenzene it was stated that one could substitute a platinum cathode for a tin or a copper cathode, provided one added a tin or a copper salt to the solution.[1] It looks, therefore, as though we were really dealing with the chemical action of the pulverulent metal on the substance to be reduced, and that the current merely regenerated the reducing agent. This brings out again the importance of studying the electrochemical phenomena with special reference to the chemical phenomena. The recent work of Tafel[2] shows that some of the mysterious changes in cathode efficiencies are due to the precipitation of minute quantities of platinum, and we have long known about the disastrous effects of platinum on storage cells. In spite of the excellent work that has been done on the electrolytic reduction of nitrobenzene, the relation between the chemistry and the electrochemistry has not always been kept in mind. Mr. J. M. Bell was once good enough to tabulate and compare for me the chemical and electrochemical methods for preparing the different reduction products of nitrobenzene. The parallelism between the two was distinctly not striking, and there is still much good work to be done in this field.

A Mechanical Device for Keeping Ice Off Racks in Water-Power Plants.

In reply to a question in the question box at the recent convention of the Canadian Electrical Association, asking if any satisfactory mechanical appliance had been found for keeping ice off the racks in water-power plants, Mr. A. A. Dion described the apparatus used by the Ottawa Electric Company, Ottawa, Ont. This device was tried last winter with complete success. It was designed by Mr. W. H. Baldwin, superintendent of the hydraulic works of the company.

The ice rake consists of a metal rake attached to a wooden beam about five inches square and twenty feet long. To this rake an up-and-down motion is given by means of a small motor. This motion causes the rake to scrape the ice rack from top to bottom and from bottom to top, the lever being balanced so that gravity keeps the rake in contact with the rack. The rake and driving motor are mounted on a small truck running on a track at the top of the platform. The rake travels up and down at the rate of 100 feet per minute. Power is transmitted to it from the motor through friction cones, bevel gearing, and a chain and grooved wheels, the chain being fastened to the rake beam.

[1] Chilesotti, *Zeit. Elektrochemie*, vii 768 (1901).
[2] *Zeit. Phys. Chem.*, lii, 349 (1905).

Wireless Telegraphy in German Southwest Africa.

An account of the use of wireless telegraphy in the campaign in German Southwest Africa has been published by the Militär-Wochenblatt, of Berlin. A brief résumé of this is given in the *Electrician* (London), September 15.

Early in 1904 an advance in separate columns was thought objectless on account of the difficulty of keeping up communication between the several columns, the impossibility of obtaining a general view of the country, and the absence of maps. The arrival of three portable wireless telegraph sets, each complete with apparatus, balloons, kites and cable packed in two wagons and a cart, made advance in separate columns possible and profitable. The personnel of the whole detachment consisted of four officers, four non-commissioned officers, and twenty-seven men. Only the officers had been trained in the use of the apparatus. It was found that with these sets, tape messages should be taken at fifty to sixty miles, but this method was almost entirely abandoned for receiving by ear, which enabled communication to be maintained up to a distance of 100 miles. In January of this year a second detachment of three sets was sent out, and the personnel of each detachment was brought up to four officers, nine non-commissioned officers, and seventy-nine men. In this case the men had also been trained in the service.

There is now permanent communication between Aminuis and Keetmanshoop, a distance of 280 miles of difficult country. Besides the two stations at each end, two intermediate stations are required. Communication is also maintained between Keetmanshoop and Hafuur, a distance of about 112 miles, for which only one extra station is required. There are thus five stations in operation. The sixth station is at present out of order.

The land in German Southwest Africa is high above sea level. The balloons have therefore less lifting power, so that the stretch of cable falls below the required 220 yards. The dryness of the atmosphere sets up frictional electricity which at times threatens to set the balloons on fire. Generally there is freedom from this disturbance between 5 A. M. and 9 A. M. Strong whirlwinds are frequent, particularly at midday. The balloons or kites are sometimes hurled perpendicularly into the bush. Some balloons were carried away by the wind and lost. The balloons, while serving to reveal the whereabouts of one column to another, also revealed the presence of the column to the enemy. The apparatus suffered a good deal from the dryness of the climate.

Utilization of Victoria Falls.

At the recent meeting, in South Africa, of the British Association for the Advancement of Science, a paper was read by Mr. Robert Hammond entitled "Electric Power Distribution for the Rand." The following abstract of this paper is given in the London *Times:* "there were no engineering difficulties in the way of supplying electrical energy to all the mines on the Rand from a central power-house utilizing the Victoria falls, but the cost would far outweigh the annual outlay on coal. He sketched in detail a more economical scheme for distributing power by burning coal nearer the Rand. He estimated that they would be able to supply power at the rate of 0.7 penny per unit, and he had little doubt that those now using steam power would find it economy to adopt electric power."

During the discussion, Professor W. E. Ayrton said in part: "the pioneering development which American enterprise had brought about, combined with the extraordinary commercial success which electric power distribution had won on both sides of the Atlantic, made people ask, 'Is such an industrial revolution in store for South Africa?' At first sight the answer was 'No,' in view of the fact that coalfields blackened the map, and the produce of some was reported to be nearly equal to the best Welsh. On the other hand, he pointed to the experience of South Wales and Tyneside, where electric power was now largely utilized. Considering the possibilities of Victoria falls, and contrasting them with Niagara, he stated that the water which was utilized, and which would ultimately cease to pass over Niagara, would be nearly five times as large as the total amount passing over the Victoria falls at the present moment. A convenient spot for a power station was at the end of the second gorge, but he advised them jealously to guard the beauty of the falls. While he advocated the electric transmission of power, he thought they should not start by constructing a transmission line from the falls to Johannesburg, not because it was unworkable, but because there was not yet sufficient demand for power along the route."

Mr. Alexander Siemens thought that individual users could construct power-houses and generate their own electrical power as cheaply as they could get it from a central station.

Ore Unloaders at the Docks of the Lorain Steel Company, Lorain, Ohio.

ONE of the most interesting and notable examples of the remarkable advance in modern industrial appliances is that to be found in the ore-unloading equipment of the Great Lakes. The ore-unloading facilities of the Great Lakes are far in advance of those in any other part of the world, and at not even the largest ocean ports is reached the marvelous speed of unloading and handling which has been obtained at modern lake docks.

A notable type of the modern equipment employed for the purpose, in fact, the one holding the world's record for fast ore unloading, is the Hulett automatic ore unloader, invented by Mr. Geo. H. Hulett, third vice-president of the Wellman-Seaver-Morgan Company, Cleveland, Ohio, which is sole builder of the machines.

The general view herewith (Fig. 1) shows the latest installation of these unloaders; namely, two electrically operated machines at the United States Steel Corporation's National Tube Company's docks at Lorain, Ohio.

An idea of the heavy service required of these machines may be gathered from the fact that they rapidly handle an enormous grab bucket, which, when open, has a spread of over eighteen feet, and which automatically digs and conveys from the hatches of the boat ten gross tons of iron ore at a load. This bucket when open can by telescopic motion be extended still farther, so as to reach more than half-way from the centre of hatch to hatch. It is carried at the lower end of a vertical dependent leg suspended from a long pivoted walking beam, which is carried on a carriage or trolley which travels back and forth on the girders of the machine. The operator who controls all the motion of the bucket rides at the lower end of the leg directly above the bucket. By means of hoisting mechanism, the walking beam is made to oscillate up and down, carrying the bucket down into the hold of the boat and up again above the dock. The leg carrying the bucket is mounted on rotating trunnions in the walking beam so that it can rotate in a circle when operating in the hold of the vessel, permitting the bucket to reach out in all directions. It also travels lengthwise of the hatch to the sides of the boat; consequently the operator is able to reach almost the entire cargo.

The travel of the trolley back and forth on the girders carries the walking beam with the bucket out over the boat and back over the dock. To reduce the trolley travel as much as possible, suitable hoppers for receiving the contents of the buckets are mounted between the girders at the

FIG. 1.—GENERAL VIEW OF HULETT UNLOADERS ON THE DOCKS OF THE LORAIN STEEL COMPANY, LORAIN, OHIO.

front; these hoppers discharge into an auxiliary bucket car.

The Hulett unloaders at Lorain are provided with special cantilever extensions, designed particularly for delivering the ore on a high bank back of the machines. The bucket car travels on these cantilever extensions, automatically dumping the ore at any desired point and returning closed to its position under the hopper. The entire machine is mounted on moving trucks, enabling it to travel up and down the dock from hatch to hatch without moving the boat.

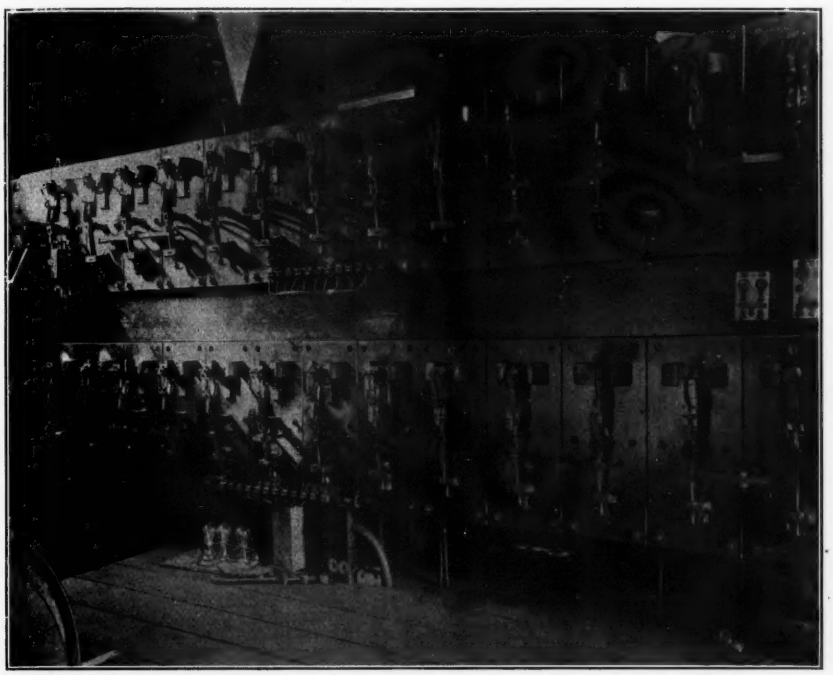


FIG. 2.—MAGNETIC CONTROLLERS FOR HOIST AND TROLLEY TRAVEL MOTIONS.

The controlling devices for machines of this type are in all cases specially constructed to meet the conditions. The controllers, proper, for this unloader consist of a number of magnetically operated clapper switches, which cut resistance in and out of the motor circuits. The switches are operated by solenoids placed on the back of the switch-panel. The main contact of each switch is a heavy laminated copper brush reenforced with a yellow brass contact, the final break being taken between carbon contacts, and the arc is quickly ruptured by a powerful magnetic blowout. The switches are controlled by small master switches located in the operators' cabs. As the solenoids of the switches require but few amperes, the wires connecting the master switch with the controller proper are of very small size.

FIG 3.—MAGNETIC CONTROLLERS FOR OPERATION OF GRAB BUCKET.

Each motion of the unloaders is provided with a positively connected or geared automatic cutout or emergency switch. The cutouts on the hoist and bucket-car motions automatically slow down and stop these motions as the limits of travel are reached. They first operate to gradually introduce resistance and slow down the motor; then change connections to convert the motor into a generator, and apply a gradual dynamic braking effect until the motion is nearly stopped, and finally apply band brakes.

The application of dynamic braking to the above-mentioned motions is of particular advantage, as the energy of these heavy parts is absorbed and dissipated in the resistance, thus removing practically all wear from the solenoid band brakes. Under these conditions, the band brakes operate as holding brakes and are required to stop the motion only upon failure of current supply.

The bucket rotation and trolley motions are supplied with geared automatic slow-down and cutout devices, which gradually insert the resistance and finally apply solenoid band brakes to stop the motion as the limits of travel are approached.

While all of the automatic devices fully protect the machinery and motors against failure of current supply, confusion and faults of the operator, still they allow the operator full control of the motors at all times, with the exception that he is unable to pass a predetermined limit of travel of the motions.

The main controllers are located as near to their respective motors as possible, so that the heavy wires carrying large currents are made as short as possible. The master switches, or controllers, are small, thus allowing such an arrangement that all operating handles are brought within easy reach of the operator. They are very easily operated and do not fatigue the operator, thus allowing full output of the machines at all times irrespective of the physical condition of the operator.

The magnetic controllers, which con-

trol the movement of the bucket in and out of the boat and the raising and lowering of this bucket, are shown in Fig. 2.

Fig. 4.—Magnet Controller for Bucket Rotation Motor.

To the left, there are seen four pairs of two switches each interconnected by means of horizontal levers. These are the reversing switches, and the function of the levers is to absolutely prevent the closing of both reversing switches at the same time. To the right are seen three switches interconnected by means of two levers. The function of these levers is to prevent

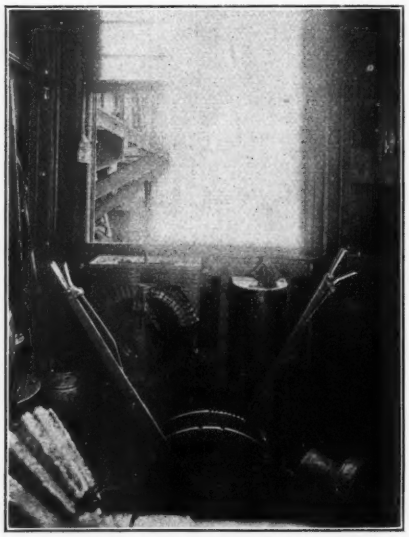


Fig. 5.—Bucket Car Operator Cabin.

the closure of the middle or dynamic braking switch when the motor is still connected to the line and operating as a motor. The levers are also used to hold open the switches at either side of the centre switch when the motor is acting as a generator with the centre switch closed.

Fig. 3 shows the magnetic switch controller for the operation of the grab or clam-shell bucket. The smaller switches, at the left, are the accelerating or resistance switches. These switches are so connected that the succeeding one depends for its closure upon the closure of the one preceding. One terminal of the operating solenoid of each switch is connected to such a point on the resistance that the current taken by the motor upon the closing of the preceding switch must fall to a certain predetermined value before the following switch can close. This means that the motor must come up to a speed corresponding to each accelerating switch before the following switch will close. This results in the smoothest possible acceleration in the shortest possible time consistent with safety to motor and

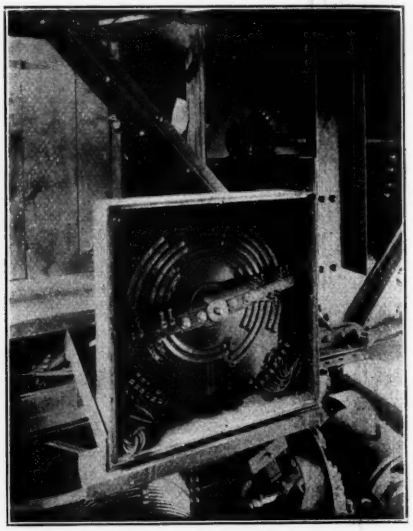


Fig. 6.—Automatic Slow-Down and Cutout Switch for Bucket Car Motor.

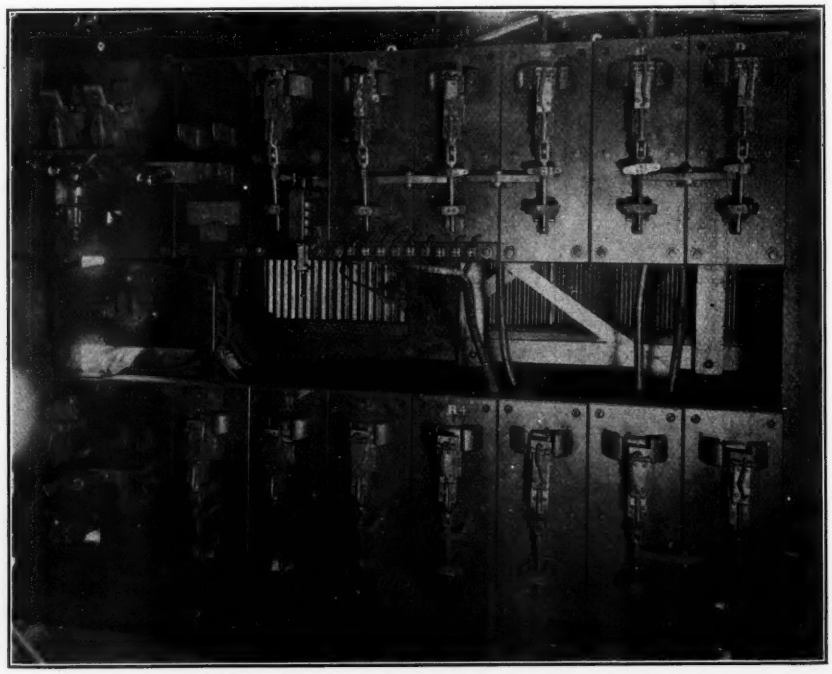


Fig. 7.—Magnetic Controller for Bucket Car Motor.

driving mechanism, and makes acceleration of the motor entirely independent of the operator should he throw the master switch with extreme rapidity.

The result of this design is to cause the motor to approximate almost exactly the operation of a hydraulic or steam cylinder; that is, it will keep a predetermined pressure on the bucket jaws and will not exceed this pressure. The motor is generally stalled once during every closure of the bucket, and this occurs without injury to the motor, controller, or attached mechanism.

The master controller for operating the bucket rotation motor is shown in Fig. 4. This motion operates so easily that the controller is small and requires but few steps.

Fig. 7 shows the magnetic switch controller operating the bucket-car haulage motor. The ore is dumped from the bucket into a car which is pulled up the incline by a motor located in the machinery house underneath the trolley. The car is automatically dumped near the end of its travel by means of mechanical dogs.

Figs. 4 and 5, respectively, show the master controller and automatic slow-down and cutout switch which control the motion of the car. The manually operated controller to the left of the master controller is used for the purpose of slewing the entire machine so that it may be brought parallel to the hatches of the boat; this dock being built on a large curve makes this motion necessary to secure the best operation. The main controller house is located on the trolley underneath the walking beam and is divided into two parts, one part containing the machinery and controllers, and the other, the resistances.

This type of control was designed, developed and built by the Electric Controller and Supply Company, of Cleveland, Ohio, which also manufactured and supplied all magnetic cushion-type solenoids for band brakes and all other electrical details.

Citizens' Telephone Company.

The annual report of the secretary of the Citizens' Telephone Company, of Grand Rapids, Mich., for the year ending June 30, 1905, shows that on July 1, 1905, there were 19,742 telephones in service, as against 16,338 for the same period last year, a growth of 3,404 telephones. The company now has 1,352 miles of poles, 1,948 miles of copper circuits, and 1,060 miles of iron circuits, making a total of 3,008 miles of long-distance circuits, or 6,016 miles of wire. The company has been making extensive improvements, putting in all-copper circuits in many localities. The automatic system of operation has been introduced very successfully at Grand Rapids and at Battle Creek, and a semi-automatic service has been installed at Traverse City and Cadillac. So rapid has been the growth of the Grand Rapids exchange that the installation of the eighth thousand of automatic switches is now being completed. The automatic system is manufactured by the Automatic Electric Company, Chicago, Ill.

The Street Railway Accountants' Association of America.

The following officers and committees of the Street Railway Accountants' Association of America have been elected for the season 1905-1906.

President, Walter B. Brockway, general auditor Nashville Railway and Light Company, Yonkers, N. Y.

First vice-president, P. S. Young, comptroller Public Service Corporation of New Jersey, Newark, N. J.

Second vice-president, Robert N. Wallis, treasurer Fitchburg & Leominster Street Railway Company, Fitchburg, Mass.

Third vice-president, H. A. Ferrandau, auditor and treasurer New Orleans Railways Company, New Orleans, La.

Secretary and treasurer, Elmer M. White, assistant treasurer Birmingham Railway and Light Company, Birmingham, Ala.

Executive committee, W. G. Ross, managing director Montreal Street Railway Company, Montreal, Canada; C. L. S. Tingley, second vice-president American Street Railway Company, Philadelphia, Pa.; F. Dabney, assistant treasurer Seattle Electric Company, Seattle, Wash.; J. H. Pardee, general manager Rochester & Eastern Rapid Railway Company, Canandaigua, N. Y.

The Colorado Electric Light, Power and Railway Association.

The annual convention of the Colorado Electric Light, Power and Railway Association was held at Glenwood Springs, Col., September 18, 19 and 20. This convention was briefly reported in a prior issue of the ELECTRICAL REVIEW. It was very successful, and over two-thirds of the membership was represented. The programme for the three days' sessions included the reading of a number of papers and the discussion of an extensive question box.

The following officers were elected for the year: president, F. W. Frueauff, general manager, Denver Gas and Electric Company; vice-president, William Mayher, manager, the Greeley Power and Light Company; secretary and treasurer, George B. Tripp, general manager, Colorado Springs Electric Company.

The officers and J. A. Beeler, president Denver City Tramway Company, and J. F. Vail, general manager Pueblo & Suburban Traction and Lighting Company, form the executive committee.

The finance committee is as follows: D. S. Harper, Trinidad; P. R. Stout, Central City; H. N. Gilbert, Pueblo.

The membership committee is as follows: J. J. Cooper, Denver; J. E. O. Blackall, Denver; B. K. Sweeney, Denver.

Advisory committee—William T. Wallace, Cañon City; E. J. Temple, Boulder; R. L. Goodale, Colorado Springs; A. M. Ballou, Denver; W. J. Barker, Denver.

Electric Power in a Brewery.

Electric motors have been installed recently in a brewery at Dartford, England, where they have been most successful. A brief description of this plant is given in the *Electrical Review*, London, for September 8. They are particularly advantageous because the demand for power is intermittent, and the motors themselves are clean. There are altogether sixteen motors of varying horse-power. One—a three and one-half-horse-power shunt motor—drives a seven-hundredweight barrel hoist. In the hop house a three and one-half-horse-power compound-wound motor drives a four-hundredweight friction hoist, bringing in the hops and sugar. In the brewery proper a ten-horse-power compound-wound motor is installed for working the rakes in the mashing tun, which is the heaviest work in the brewery. A seven-horse-power shunt motor is used here for driving a screw conveyer which empties the used grains out of the tun. There is also a one-horse-power shunt motor driving sundry small machine tools. Above this floor there is a masher driven by a three and one-half-horse-power motor, and on a third floor a fifteen-horse-power shunt motor drives the grinding and malt-cleaning machines. The dust from the cleaning machines is collected in a dust-destroyer driven by a three and one-half-horse-power shunt motor. Various other hoists in this building are driven by motors. In the barley house a five-horse-power shunt motor and a three and one-half-horse-power compound motor drive a barley-cleaning machine and a friction hoist. In the malt house a seven-horse-power motor drives a belt conveyer for distributing barley and malt between the upper and the lower floors. An eight-horse-power compound-wound motor drives a malt lift on the top floor of the building. In this building there are also a dust-destroyer driven by a two and one-half-horse-power shunt motor, and two one-horse-power motors utilized for working the bottling machinery. All the machinery in the establishment, with the exception of the deep-well pump, is driven by motors. The cost of the electric driving for the six months ending June 30 of this year was about $1,240. This includes some purchased power. The cost of steam driving for the corresponding six months of the previous year was $1,922. Further, by means of the electric operation, expenses were reduced by replacing two men by a single boy, the difference in wages being ten dollars a week.

THERMODYNAMICS OF THE ELECTRIC INCANDESCENT LAMP.[1]

BY DR. E. F. ROEBER.

From a theoretical point of view the simplest electric incandescent lamp is a direct-current lamp with its filament in an absolute vacuum. We will assume the filament to be a conductor of the first class, *i. e.*, of the type of metallic conductors. The heat which is conducted away through the leading-in wires shall be assumed to be negligible.

Under these conditions there can be no loss of heat by conduction or convection, and if we neglect the energy which is consumed in throwing off particles of carbon from the filament, etc., the whole electrical energy which is supplied to the lamp must be changed into energy of radiation.

For the sake of simplicity the filament may be assumed to be a straight cylinder of the length l centimetre and with a circular cross-section of radius r centimetre. Let γ be the conductivity of the material of which the filament is made. Then the conductance is $\gamma \frac{r^2 \pi}{l}$ mhos and if e is the voltage at the terminals of the filament, the current in amperes is $e \gamma \frac{r^2 \pi}{l}$ and the power supplied to the lamp in watts is $e^2 \gamma \frac{r^2 \pi}{l}$, hence the energy radiated per second from one square centimetre of surface of the filament is $\frac{e^2 \gamma}{2} \frac{r}{l}$ = watts.

This is at least the case when the stationary condition has been reached. In the first time element after the circuit is closed, the electrical energy which is supplied to the lamp is used to raise the temperature of the filament and the temperature will continue to rise until it reaches that value for which the total energy radiated equals exactly the electrical energy supplied to the lamp.

For a given filament and for a given temperature of the surroundings the total energy of radiation depends on the temperature of the filament only; and if we introduce the further assumption that the filament is a perfectly "black body" (*i. e.*, according to Kirchhoff's definition, one which absorbs all radiations falling on it and neither reflects nor transmits any), we can directly apply the Stefan-Boltzmann law.[2]

According to this law, the total energy of radiation from a black body equals $K (T^4 - T_0^4)$, where T is the absolute temperature of the radiating filament, T_0 the absolute temperature of the surroundings, and K a constant.[1]

In our special case we, therefore, get

$$(1) \qquad \frac{e^2 \gamma}{2} \frac{r}{l^2} = K (T^4 - T_0^4).$$

This equation enables us to calculate the temperature of the filament if the voltage e at its terminals is given and if it behaves as a black body.

Now this total radiation consists of electromagnetic waves of an infinite series of different wave-lengths, but the physiological effect of light is produced on the normal eye only by those waves the length of which is between 8×10^{-5} and 4×10^{-5} centimetre, or the frequency between 39×10^{13} and 76×10^{13} periods per second.

The endeavor must be to get such a spectrum of the incandescent filament radiation that as much as possible of its area falls within the limits of the wave-lengths of visible light.

A first indication of the degree to which this desideratum is fulfilled is given by Wien's displacement law[2] according to which the product of the wave-length λm of maximum energy and the absolute temperature T of the radiating source is a constant:

$$(2) \qquad \lambda m T = \text{constant}.$$

If the wave-length λm is measured in centimetres, the constant[3] in equation (2) is 0.2940 for a black body.

If, therefore, the temperature of the incandescent filament increases, the maximum of energy is shifted toward shorter wave-lengths. In order to get the maximum energy within the visible spectrum, for instance at the wave-lengths 6×10^{-5} centimetre not far from the D line of sodium, the absolute temperature of the black body filament must be 4,900 degrees absolute, or over 4,600 degrees centigrade. This is far beyond anything we can hope at present to reach in incandescent lamps.

The spectral distribution of energy in the radiation of a black body is given by Wien's law[4]

$$(3) \qquad J = c^1 \lambda^{-5} e^{-\frac{C_2}{\lambda T}}$$

where J is the energy corresponding to the wave-length λ (region of spectrum λ to $\lambda + d\lambda$), T is the absolute temperature of the radiating black body, e is the base of the natural system of logarithms, and c_1 and c_2 are constants. This equation has been modified by Planck.[1] Planck's law which has been found to represent in a most remarkable way the facts throughout the extreme ranges in which it has been tested, reads as follows:

$$(4) \qquad J = C_1 \lambda^{-5} \frac{1}{e^{\frac{C_2}{\lambda T}} - 1}$$

These formulas represent the fundamental laws of the radiation of a black body.

In practice the efficiency of a lamp is not given as the ratio of the energy of radiation within the visible spectrum to the total radiation, but is given by the candle-power which is produced by one watt, or what is the more general, although improper commercial usage, by the reverse ratio, *i. e.*, the number of watts consumed per candle. The rays within the visible spectrum form what we call the flux of light and their energy is sometimes assumed to be measured by spherical candle-power.

The underlying idea is that the spherical candle-power is proportional to the energy of the light emitted. Now, as long as we have to do with light of one single wave-length, this supposition is correct. But if we compare two composite sources of light, the element of the physiological effect enters into the measurement of the candle-power since the intensity of the physiological effect depends on the wave-length. On the other hand, the energy of light has a distinct value independent of whether it produces any physiological effect or not.

It is, therefore, strictly correct only with monochromatic light to assume the candle-power to be a measure of the energy of visible radiation; and for this reason it is proper only for single wave-lengths to try to find a numerical relation between spherical candle-power and the usual units of power—or, as we may say, the mechanical equivalent of light.

Since the physiological effect on the normal eye is a function of the wave-length, the relation between candle-power and other units of power must also be a function of the wave-length.

Nevertheless in practice we compare different sources of light—of different spectral composition—by their candle-power. In such cases we average the physiological

[1] Abstract of paper read at the recent meeting of the American Electrochemical Society, Bethlehem, September 20.

[2] Stefan, *Ber.* d. K. Akad. der Wissensch., Wien, vol. lxxix, B, 2 Abth., p. 391, 1879; Boltzmann, *Wiedemann's Ann.*, vol. xxii, p. 291, 1884.

[1] For numerical determinations of K see F. Kurlbaum, *Wiedemann's Ann.*, vol. lxv, p. 759, 1898.

[2] Wien, *Weidemann's Ann.*, vol. xlvi, p. 633, 1893; vol. lii, p. 132, 1894.

[3] Lummer & Pringsheim, *Vern.* d. Deutsch. Phys. Ges., v. i, p. 218, 1899.

[4] Wien, *Wiedemann's Ann.*, vol. lviii, p. 662, 1896.

[1] *Berichte*, der K. Akademie d. Wissenschaften, Berlin, p. 544, 1901.

effects of the energies of the different wave-lengths.

The results obtained by experimental determinations of the mechanical equivalent of light, if not limited to a single wave-length, must therefore be taken *cum grano salis*[1], although they undoubtedly are interesting as giving a first approximation to the truth.

Experimental researches on this problem have first been made by J. J. Thomson and O. Tumlirz.[2] The result of Tumlirz was 0.188 watt per spherical hefner-candle. However, his method of measurement was open to objections, since he separated the visible spectrum from the other rays by trying to absorb the latter in a layer of water. This must lead to too high a numerical value of the watts per candle, as was more recently pointed out by K. Angström[3] who made another determination of the mechanical equivalent of light. In order to separate the visible spectrum from the balance of the spectrum, he decomposed by refraction the total radiation into the rays of different wave-lengths, cut off all rays except those with the visible spectrum and recombined the latter by means of a lens. His result appears to be the best available at present.

Angström found that the equivalent of the light radiation of one hefner candle per square centimetre at a distance of one metre (one meter candle) is 8.1 ergs per second. This gives as the equivalent of one spherical hefner candle 0.102 watt. This is almost one-half the equivalent of Tumlirz:

Now one spherical hefner is equal to 0.88 spherical (British) candle-power. We, therefore, get, as the result of Angström's determination, for 100 per cent efficiency.

1 spherical candle-power = 0.115 watt

or

1 watt = 8.63 spherical candle-power.

One of the most efficient new types of incandescent lamps, the tantalum lamp, consumes initially 1.99 watts per mean horizontal candle-power and 2.78 watts per mean spherical candle-power; while the average value throughout life was found as 2.19 and 2.70 watts respectively, according to recent tests made in a testing laboratory in this country. For the efficiency calculation the watts per spherical candle-power must be chosen, and if we base this calculation on 2.70 watts and on Angström's equivalent, it follows that the tantalum lamp has an efficiency of 4.3 per cent.

An ordinary carbon filament incandescent lamp if consuming 3.1 watts per mean horizontal candle-power and 3.9 watts per mean spherical candle-power has an efficiency of 3.5 per cent.

We have now reached the problem, what can be done to make incandescent lamps more efficient?

One obvious conclusion from the above discussion is, that if we want to employ a black body filament we must increase the temperature of the glowing filament very materially.

The carbon filament of the old ordinary incandescent lamp has often been assumed to come pretty near a black body. Now, it will at once be seen that we can easily increase the temperature T of the filament by increasing the voltage *e;* equation (1) gives the exact variations of T with *e*. If we do this, the maximum of energy in the spectrum will be shifted toward shorter wave-lengths according to (2); *i. e.*, the light gets better, whiter, more like sunlight in spectral composition. As a necessary concomitant, the area of the energy curve, which falls within the visible spectrum, increases; in other words, the efficiency increases.

It can be laid down as a general rule that the color effect of the light of an incandescent lamp enables one to judge approximately the efficiency at which it burns. The reason is that according to the above theory both the color effect and the efficiency are functions of the temperature. In a private communication to the writer Dr. Louis Bell gives the following color scale of efficiencies of ordinary carbon filament incandescent lamps.

Watts per Candle-Power.	Color.
1.5.....	clear white.
2.0 to 2.5	white, very faintly tinged with yellow.
3.0.....	yellowish white.
3.5.....	yellowish.
4.0.....	yellowish, tinged with orange.
4.5.....	orange yellow.
5.0.....	distinctly orange red.

Lummer[1] refers to a test of a lamp of sixteen spherical candle-power, which when operated at forty-five volts gave sixteen candle-power, thus consuming 3.5 watts per spherical candle-power; the voltage was raised and with it the electrical power supplied to the lamp to 266 watts; simultaneously the candle-power increased to 2,000, representing a consumption of 0.13 watt per spherical candle-power (which is almost the theoretrical limit according to Angström's equivalent). Thus an increase of energy in the ratio from one to five corresponds to an increase of candle-power from one to one hundred and thirty and to an increase of efficiency from one to twenty-six. But the lamp burns out at once.

If a black body filament is to be used, the progress must be looked for in an increase of its temperature. This is the reason for trying metals of very high melting points for filaments; such as osmium in Dr. Auer von Welsbach's osmium lamp, since osmium has the highest melting point of any known metal. The same principle was followed in the systematic development of the tantalum lamp of the Siemens & Halske Company, by Dr. von Bolton, who tried the following metals one after the other: vanadium, niobium, tantalum. Their melting points are 1,680 degrees, 1,950 degrees, and 2,250 to 2,300 degrees centigrade, respectively. On account of its highest melting point tantalum was finally chosen.

However, by simply increasing the temperature we can not get very far toward the realization of the ideal if a black body filament is used. We saw before, that according to Wien's displacement law, we would need to use a temperature of more than 4,600 degrees centigrade, *i. e.*, more than 8,000 degrees Fahrenheit to get the maximum of energy at 0.6 μ. There is no hope of coming near such a temperature in present practice.

But fortunately, there is no necessity whatever to use a black body filament. A black body is an ideal case in thermodynamics; it is nowhere strictly realized in practice. But the black body is not at all the ideal thing for the lighting engineer. On the contrary, the further we can get away from the black body the better for us.

The above discussion was based on the consideration of the black body filament, because on this matter we can speak with certainty and without vagueness. The discussion of filaments departing from black body radiation can be carried out only in special cases with similar mathematical exactness. In general we must be satisfied to indicate the direction in which the results will vary from black body radiation.

At a given temperature the total radiation from a non-black body is less than from a black body. Hence if we substitute a non-black body filament for the black-body filament, leaving everything else unchanged, our fundamental equation (1) will no longer be valid. The stationary condition, represented by the equality of radiation energy and electrical energy

[1] See, for instance, C. J. Reed, *Electrical World and Engineer*, vol. xxxvi. p. 170, 1901, also the editorial in the same volume, p. 247.

[2] See the summary of their researches in an article by C. Hering, *Electrical World and Engineer*, vol. xxxvii, p. 631, 1901.

[3] K. Angström, *Physik. Zeit.*, vol. iii, p. 257, 1902.

[1] Lummer, *Zeit. f. Beleucht.*, March 20, p. 97, 1904.

supply, necessitates now a higher temperature T than with a black body filament.

Of greater importance, however, than the total radiation is the distribution of the energy of radiation over the whole spectrum. Non-black body radiation is essentially selective radiation. The real ideal thing about the black body is that, according to definition, its radiation is not selective, since it absorbs all rays of any wave-length and, therefore, according to Kirchhoff's law of the parallelism between radiation and absorption it also radiates all of them.

The ideal filament for the lighting engineer must be one which absorbs only rays within the visible spectrum, while it either perfectly reflects all other rays or is perfectly transparent for the same. Such a body would then emit a radiation completely within the visible spectrum.

It serves no useful purpose to speculate whether we have any prospects of realizing such an ideal filament body. Instead, we may briefly state what we know concerning polished platinum which is one of the bodies which of all those tested shows the greatest departure from a black body.

In Wien's displacement law (2) $\lambda m T =$ constant, the constant is 0.2940 for the black body and 0.2626 for polished platinum (Lummer and Pringsheim), when the wave-length is measured in centimetres. Hence the absolute temperature T at which the maximum of energy lies at a certain wave-length is less by about ten per cent with polished platinum than with the black body. This means that heated to the same temperature, a polished platinum filament will have a spectrum with its maximum of energy nearer to the visible spectrum than a black-body filament. Nevertheless, polished platinum is still very far from the ideal material which the lighting engineer must aim at.

No rule can be laid down how to devise such an ideal material, except to determine empirically the absorption of all possible substances for all different wave-lengths.

However, the degrees of departure of a body from black body radiation does not depend solely on its material, it also depends to a certain degree on the condition and the configuration of its surface. The more porous the body the more will it behave like a black body.[1]

The realization of the black body in practice is based upon Kirchhoff's fundamental rule that the radiation inside an enclosure, all points of which are kept on uniform temperature, is absolute black body radiation. The black body with which the laws of radiation have been experimentally established is such a hollow enclosure, the walls of which are kept on uniform temperature, but contain a small opening through which the radiation is absorbed. The presence of the opening represents a negligible departure from absolute black body radiation.[1]

Now it is evident that any pore in the surface of an incandescent filament whatever it is made of will behave more or less like a black body. Hence we get the important result that the ideal filament must have a polished surface without pores.

In the case of the osmium lamp it has been noticed that the initial increase of candle-power, which is observed with almost every filament after the current is turned on, continues for an unusually long period, somewhat like 200 hours. This is said to be due to a continuation of the formation of the filament, the particles being better fused together and the surface getting more polished. It is quite possible that in the case of the new graphitized filament of the General Electric Company something similar goes on, since the treatment is essentially an external surface treatment, although the material of the filament itself is also changed.

While speaking of the ordinary carbon filament it was noticed above that two of the reasons of the ageing of the lamp were decrease of surface emissivity and a throwing off of carbon particles from the filament with a resulting blackening of the globe. These two effects have generally been considered to be independent of each other, although in the light of the above discussion it may be that the decrease of emissivity is due to the formation of pores or minute holes in the surface of the filament, as a result of the throwing off of small carbon particles. If this is true, the negative terminal of the filament (from which the carbon particles are mainly thrown off) should lose more in emissivity than the other terminal. I do not know whether experiments of this kind have been made. To test this suggestion it would be necessary, of course, to separate carefully the effect of change of emissivity from the effect of blackening of the globe. For this reason the globe would have first to be uniformly cleaned before the emissivity of the two ends of the filament were compared.

Without going into a discussion of the probable commercial effect of the new lamps on the electric lighting industry—which is outside of the sphere of this paper and of this society—it may be simply said that the osmium lamp and the tantalum lamp have reduced by forty to fifty per cent the consumption of power per candle-power by the ordinary incandescent lamp. However, for commerical purposes quite a number of other factors would have to be considered. With the new graphitized carbon filament the consumption of power per candle-power has been reduced by twenty per cent.

In view of the foregoing discussion it would be extremely interesting to know how far the progress achieved by the new lamps is due to the increased temperature and how far to a greater departure from black body radiation. We know of all three lamps that their filaments are at higher temperature than the ordinary carbon filament. Concerning the question, however, how far the three new filaments (in comparison with the ordinary carbon filament) depart from the black body no information of an exact nature has been published to my knowledge.

A complete investigation of these problems would involve not only a determination of the actual temperatures and of the "black body temperatures" of the filaments, but the actual distribution of the energy within the spectrum.

This would give us directly the absolute efficiency of the three lamps as the ratio of the area within the visible spectrum to the area of the total spectrum of the energy curve. It is quite possible that the numerical value of the efficiency thus determined may differ essentially from the efficiency as determined from the candle-power per watt on the basis of the mechanical equivalent of light.

The first definition is absolutely physical and leaves the physiological aspect of the problem out of consideration. In this definition each watt corresponding to one wave-length within the visible spectrum is considered as perfectly equivalent to one watt corresponding to any other wave-length with the visible spectrum, although the physiological effects may be very different. The second definition of efficiency, on the other hand, is essentially based on the physiological effect. According to the second definition the efficiency of the osmium lamp is practically twice that of the ordinary carbon lamp; but this does not necessarily mean that the efficiency according to the first definition has also been doubled. For the actual efficiency the loss of heat by conduction through the leading-in wires is also a factor; this has not been considered by the above discussion.

At all events, in spite of what has already been accomplished, it is evident that we are still far from finality.

[1] F. Blaw, *Elektrotechnische Zeitschrift*, February 23, 1905, concerning the osmium lamp.

[1] Waidner and Burgess, *Bull. Bureau of Standards*, vol. i, No. 2, p. 196, 1905.

SOME NOTES ON THE RAPID ELECTRO-DEPOSITION OF COPPER.[1]

BY SHERARD COWPER-COLES.

The author when carrying out experiments on the electrolytic production of copper tubes, which should be free from laminations, observed that if the mandrel constituting the cathode was revolved at a certain circumferential speed, smooth thick deposits of copper could be obtained at very high current densities which could not be obtained by any other method. Further investigations were made to determine this speed, and the method eventually adopted was a cathode in the form of a cone, by which means the critical speed can be determined very readily. It has been found that the tensile strength of the copper increases with the speed of rotation.

It is found that very pure copper is obtained by the centrifugal process, even when very high current densities are employed, and the solution contains much foreign matter in suspension, as shown by the following analysis of a copper sheet:

	Percentage.
Iron	0.0189
Arsenic	0.0015
Lead	0.0013
Antimony	0.0010
Bismuth	0.0008
Silver	Absent
Nickel	"
Sulphur	"
Copper, by difference	99.9765

The composition of the electrolyte usually employed is copper sulphate ten per cent, sulphuric acid ten per cent, water eighty per cent.

A great advantage of the centrifugal process is that the copper is free from lamination, such as is found when copper is burnished at stated intervals; this point has been established both by mechanical tests and microscopical examination. In the latter case specimens were cut from samples, and were polished and etched; in all cases the metal was close and homogeneous, and free from gaps, pits and fissures.

It has been found that any stoppage or great variation in the speed of the mandrel causes lamination. The nodules or excrescences that form on copper are nearly always due to a particle of dirt settling on the cathode or a bubble of gas adhering tenaciously, with the result that the copper builds up around the adhering substance, rapidly increasing in size.

Copper tubes produced by this process without any drawing have been given a maximum stress of seventeen tons, and a tube after drawing has stood a pressure of 3,000 pounds per square inch—thickness of metal 0.063 inch—without showing any signs of distress; and sheets, without rolling, have given a maximum stress of from twenty-eight to thirty-four tons (2,000 pounds) per square inch.

The production of copper wire by electrolytic means is a more difficult problem than the production of copper tubes and sheets. Various processes have been suggested and tried from time to time, such as electro-depositing copper on a thin copper wire until it has attained a considerable thickness, and then drawing the thickened wire down again to a comparatively fine wire. Swan and Sanders have both experimented with such processes, but so far they have not been worked commercially. Elmore's process consists in producing copper tubes by his burnishing process and cutting them up in long spirals. Such a process is very costly, and the wire when finished and subjected to a torsional test is very unsatisfactory. Other experimenters have tried placing insulating strips on a cylindrical mandrel so as to produce long copper spirals; the spirals thus produced are uneven and unsuitable for drawing down to wire on account of the roughnesses formed on the edges. The method employed in conjunction with the centrifugal process consists in making on the mandrel a spiral scratch. The effect of this scratch, which must be angular, is to affect the molecular structure of the copper and to form a cleavage plane; if the scratch is not angular but round at the base the copper will not divide. The line of cleavage is no doubt formed in the same way as a cast metal. The crystalline structure of the deposited copper has a line of cleavage starting with the sharp point of the scratch on the mandrel. The copper separates more readily if unwound at an angle to the axis of the mandrel. A mandrel capable of making three or four miles of wire in one operation in a few hours from crude copper may be constructed. The vat is annular, the mandrel being seven feet in diameter and making about fifty revolutions per minute. A great feature of such a vat is that there are no working parts in the electrolyte and no stuffing-boxes or glands.

The capital expenditure on plant required for the centrifugal process compares very favorably with an up-to-date rolling mill and wire-drawing plant; the cost of such a plant with buildings, engines and the necessary plant is about $400,000 for an output of about 100 tons per week or 5,000 tons per annum.

The following are some of the chief advantages claimed for the process: the copper is refined and manufactured into sheets or tubes in one operation, the copper being of a hard nature, similar to that which is cold-rolled; the process is at least ten times faster than any existing electrolytic process; a high current can be employed without deteriorating the quality of the copper; there is no risk of lamination, as no burnisher is employed; the plant is simple and free from mechanical complications, the amount of copper locked up for a given output is small compared to other processes; finally, anodes of very impure copper can be used as compared to the anode copper used in other systems.

[1] Abstract of a paper read before the Faraday Society, Monday, July 3.

The Madison Square Garden Electrical Show.

The following companies have selected space for the Madison Square Garden Electrical Show, to be held December 11-23, inclusive: National Carbon Company, Cleveland, Ohio; Eastern Carbon Works, Jersey City, N. J.; Chicago Pneumatic Tool Company, Chicago, Ill.; Electro-Dynamic Company, Bayonne, N. J.; General Storage Battery Company, New York city; G. M. Gest, New York and Cincinnati; Ovington Manufacturing Company, Boston, Mass.; Harry M. Stevens, New York city, and Joseph Goldfinger.

The New York Telephone Company is perfecting details for its exhibit. The space chosen is the circle in the centre of the promenade, directly in the middle of the Garden. This circle is some thirty feet in diameter, and over it will be hung an enormous blue bell covered with incandescent lights.

Among other interesting exhibits in this booth there will be a model telephone central exchange. This central station will be a working exhibit, as will practically every other exhibit in the Garden. During the show each exhibitor will have a telephone in his booth connected to this exchange, so that business may be continued throughout the day and evening.

National Electric Light Association Convention Entertainment.

The recent convention of the National Electric Light Association, at Denver and Colorado Springs, Col., was unusual in several respects. It has just been announced that, although the entertainment features were very elaborate, Mr. R. B. Sullivan, chairman of the local finance committee, has returned to subscribers to the entertainment fund fifteen per cent of their subscriptions. As there is usually a shortage of funds for conventions, this is regarded as remarkable.

THE SINGLE-PHASE RAILWAY SYSTEM.[1]

BY CHARLES F. SCOTT.

It is the purpose of this paper to present some of the salient features of the single-phase railway system which may be of particular interest to the members of the American Street Railway Association.

The questions which a railway manager is apt to raise with regard to the single-phase railway concern its suitability for his particular conditions, its present practical status and its cost. The answers which apply in one case may be misleading in others, so that the discussion of the subject must be general rather than particular.

There are two other questions which have been asked so often that they deserve a passing comment. Will the motor start with good torque and accelerate rapidly? Will it commutate? Suffice it to say that the single-phase motor of the variety which I am considering does start and accelerate and commutate. It is not the motor itself but the single-phase system which the motor makes possible that is of prime importance. And the system is of commercial value only as it is able to operate electric railway service more effectively and economically than is practicable by other means.

SINGLE-PHASE AND DIRECT-CURRENT SYSTEMS COMPARED.

The single-phase system accomplishes the same results in car movement that may be obtained by direct-current equipments, but in many cases with less first cost, less operating expense, increased flexibility and greater simplicity.

The radical difference between railway systems using direct-current motors and those using single-phase motors is not so much in the car or the power-house as it is in the circuits connecting them. In the first place the high voltage used on the trolley wire does away with expensive feeders and it also enables the current to be carried to a greater distance from the power-house or from the substation. Second, the substation employed in the single-phase system requires simply a lowering transformer. The substation for supplying a direct-current railway requires the rotary converter and a set of lowering transformers. Third, the number of substations for a single-phase road is less than is required for direct current and these do not require the attendance which is necessary for the operation of rotary converters. It is these characteristics that peculiarly adapt the single-phase system to interurban and long-distance railways.

CONSTITUENT PARTS OF SINGLE-PHASE SYSTEM.

The motor is the feature which has received particular interest and comment, for it has been conceded that if a single-phase motor be available the other elements would follow as a matter of course. No one has questioned the adaptability of control apparatus, transformers and high-tension line construction to the requirements of the single-phase railway system. This simply involves the application of well-known apparatus and methods to the particular requirements of railway operation. But a perfected motor does not mark the completion of development work. Control apparatus for handling alternating current must be devised and constructed. It must be suitable for hand control for small cars and it must be adapted for the multiple-unit operation of heavier equipments. Still other forms must be suitable for operation interchangeably on either direct or alternating current. Transformers, line switches and other auxiliaries must all be combined into a workable equipment. Forms of trolley and overhead construction must be developed suitable for the new conditions of current and voltage. The announcement of a commercial single-phase motor made in the paper of Mr. Lamme before the American Institute of Electrical Engineers three years ago this month was necessarily the beginning rather than the end of the development of the system as a whole in all its details.

ADVANTAGES PROVED BY SERVICE.

In how far have the advantages claimed for the single-phase system been realized? Among the important features are the following:

A high-voltage trolley construction has been developed and has proved to be simple, strong and thoroughly practicable. Thirty-three hundred volts has been used and has proved to be safe and reliable.

A sliding contact device which does not require reversing when the direction of the car is changed is found more satisfactory, especially for high-speed operation, than the trolley wheel. Its wearing surface lasts longer than trolley wheels operating lighter cars on direct current.

Transformer substations supply current satisfactorily without feeders and without station attendants.

The car equipments show simplicity and effectiveness in the control apparatus. Less than half the controller notches required for direct current give equally smooth and as rapid acceleration with alternating current. Platform controllers are simpler as no magnetic blow-out is required. The unit control system is readily adapted for the operation of single-phase motors and is in some points simpler than the control of direct-current motors.

The operation interchangeably by alternating current and by direct current is a feature of an important road which operates large equipments on direct current in the city and on alternating current across country.

Motors of four or five sizes have been built and show excellent commutating features. The commutators take a good polish. The motor windings are such that there is a practically balanced magnetic pull, even if the armature be slightly out of centre. Although the armature speed is higher than in corresponding direct-current motors, the advance criticism has proved ill-founded as there have been no bearing troubles. The oil lubrication has proved highly satisfactory.

The foregoing features, which are the important elements upon which the claims of the single-phase system are based, have been shown by actual operation to be entirely feasible and practicable, and such as to inspire confidence.

Difficulties have been met which have been annoying and vexatious. The difficulties, however, have usually been due to some error in the general engineering features or to some specific point of weakness in the insulation or construction of some part of the apparatus. In other words, the troubles have not been fundamental and inherent in the single-phase system, but have been incidental and capable of ready remedy. Some particular difficulties will be taken up further on in this paper.

LEADING FEATURES OF SINGLE-PHASE SYSTEM.

As a guide to determine the conditions under which the adoption of the single-phase system is advantageous, it will be useful to review briefly some of its features which are particularly concerned in its installation and operation.

The Motor—A motor which is protected from the trolley voltage and lightning disturbances by an intervening transformer winding, which has only 200 to 250 volts across its terminals, which may have its brushes grounded or short-circuited with-

[1] A paper prepared for the twenty-fourth annual convention of the American Street Railway Association, Philadelphia, Pa., September 27 and 28, 1905.

out "flashing" or "bucking" and which may have full voltage thrown on its terminals without disaster to itself is essentially a safe motor. The armature has a bar winding on sizes of thirty horse-power and upward. The increased current required at low voltage necessitates brush capacity equivalent to that on a direct-current motor of twice the output.

The Control—One usually thinks of the direct-current street railway motor as a variable-speed motor. Yet it is, in a sense, fundamentally a one-speed motor, for with definite applied voltage, weight of car and grade, the motor soon attains a definite speed at which it continues to run until there is a change either in the voltage applied or in the load. If two motors be operated in series there is a second definite speed, which is about half of the speed when they are in parallel. Other speeds are obtained by lowering the voltage on the motor by means of resistance, but this is inefficient and is admissible only in starting.

Certain results follow. The speed of the car depends upon the trolley voltage. If the voltage be low, the speed is low. The efficient speeds are fixed by the trolley pressure and not by the motorman. The relation between speed on level and the speed on grade is fixed by the inherent characteristics of the motor. A given motor with definite gear ratio has its one definite speed depending upon train resistance and electromotive force. There is no range of adjustment like the throttling of an engine without the introduction of the wasteful rheostat. In a series motor the current determines the torque and the electromotive force determines the speed. Hence, for speed control there must be voltage control. In the direct-current system efficient voltage control is not attainable, but with alternating current it is easily secured. The simplest method of variable voltage is by means of taps from the transformer winding. The low voltage required for starting is obtained from a low tap and the successively higher voltages for increasing speeds are secured from successively higher taps from the winding. As there is no rheostat the motor may run efficiently from any tap, thereby giving the motorman a control over his car movement which is not possible with direct current. If there be a tap giving a voltage higher than that required for normal running it is available for giving a higher speed for making up lost time, or for supplying normal voltage to the motor when the line pressure is low. The car can run at any time at the pressure needed.

The number of points required on the controller for smooth acceleration is much less with alternating than with direct current. The whole control system in fact is simply half a dozen taps from the transformer to the controller by means of which any one of them may be connected to the motor. An intervening preventive coil enables the controller to pass from one point to the next without opening the circuit or short-circuiting the two taps. The controller may consist of a drum of ordinary form on the car platform, or of unit switches placed under the car and operated by a master controller. The latter type is used in heavy equipments and also when several cars are to be operated in the multiple-unit system. An effective form of switch with magnetic blow-out has been developed for heavy currents. The switches are assembled in a compact group, thoroughly protected and easily accessible.

Trolley Voltage—Twenty years ago the electric railways of the United States as measured either in miles, in cars or in kilowatts comprised less than one per cent of what they do to-day. In this enormously rapid growth two features of the electric railway have remained unchanged, although other elements have been greatly modified. These two features are: first, the series motor; second, the use of direct current at approximately 500 volts. During this time the generating plant has changed from small belt-driven to large direct-connected units and then from direct current to alternating current. High-tension transmission circuits with rotary converter substations have been common. Motors have increased in size and have been improved in design and in reliability and the multiple-unit system of control has been introduced for larger equipments. The trolley voltage, however, has been limited to approximately 500 volts on account of the limitations of the direct-current motor and the inability to transform direct current on the car from a high voltage to a low voltage. The general trend of electrical engineering has been toward alternating current at high voltage. Many can remember the time when the use of 1,000 or 2,000 volts was decried as impracticable or unsafe and when 5,000 or 10,000 volts was the limit to laboratory experiments. Progress has been made in design, in construction and in materials until voltages, which not long since were impracticable, are now operated with greater reliability and safety than were the lower pressures a few years ago. Safety is very largely a question of mechanical excellence. In railway motors and control apparatus, in the mechanical equipment of heavy and high-speed cars, in overhead construction and in power-house equipment, reliability is primarily dependent upon mechanical excellence.

While any considerable increase in voltage may not be safe on existing trolley lines, it is practicable by an increase in mechanical strength to offset the higher pressure and produce a high-voltage trolley system of greater reliability and safety than the present construction for low voltage affords. Such a construction has been developed into a commercial form in the catenary suspension of the trolley wire. An auxiliary steel cable with a moderate sag at the centre of spans supports every few feet of trolley wire which is thereby maintained at a uniform height. It is adapted for high-speed running and it possesses a greatly increased strength. The excess cost of the catenary construction over the cost of poles and overhead construction of the ordinary type is moderate and in a large measure is justified by the gain in mechanical reliability quite aside from the question of voltage.

The Substation—To one familiar with an ordinary rotary converter substation interest will centre chiefly in the negative characteristics of the single-phase substation. There is no rotary converter—a most essential link in the old system, one which behaves remarkably well when all is favorable; that is inclined to be fussy and obstreperous when the conditions are not to its liking. There is no synchronizing, no sparking, no flashing, no dropping out of step. The transformers are arranged not in banks of two or three little ones, with polyphase switches and auxiliaries in primary and in secondary, and the direct-current switchboard has disappeared entirely.

So much for what it is not. In its simplest form the substation is a single transformer with its primary and secondary connections. Additional transformers, switches, lightning protection, and instruments are added as circumstances require.

Short-circuits have lost much of their terror. The alternating current on short-circuit is limited by the self-induction of the circuit, and a transformer is not disturbed by a "short" as is the commutator and the speed of a rotary converter.

The difference in the effect of a short-circuit on direct current and on alternating current is well illustrated in the underground circuits in New York city. In a 11,000-volt cable system a fault in the cable causing a short-circuit is usually confined within the cable and merely burns

out a few inches of the conductor before the circuit-breaker opens. On a low-tension system, however, the currents are very large and considerable lengths of the conductor may be melted before the current is cut off. In an alternating-current system the normal current on a circuit delivering a given amount of power is less in proportion as the voltage is increased and, as the increase of current above normal is not as great on account of the self-induction of the circuits and apparatus, accidents are less liable to be destructive.

Operation on Direct Current—If the single-phase road is to be an extension of an existing road it may be desirable to run the single-phase cars over the tracks which have a direct-current trolley wire. While single-phase cars can be arranged to operate from a direct-current trolley wire, it handicaps in some measure the single-phase equipment. The addition of resistances to the car equipment and the extra switches and the like for enabling the change to be made in the current supply are obviously objectionable. It is best, therefore, to keep single-phase equipments free from operation on direct current if it be practicable to do so. When it is found necessary for single-phase equipments to operate from direct-current trolley wire, the motors are connected two in series for 500 volts, and if there be four motors the two pairs are connected first in series and then in parallel, as in ordinary series parallel control. The transformer is cut out, and the control apparatus and motors operate in substantially the same way as those on an ordinary car.

SOURCE OF POWER.

The standard frequency for the single-phase motor is twenty-five cycles (3,000 alternations). Generators may be wound for single-phase, or direct current may be taken from one phase of a two-phase or a three-phase generator. Current from the several phases of a polyphase generator may be used for operating different divisions of the railway.

If power is to be taken from a power-house which generates a higher frequency, it can not be applied directly, but must be changed to twenty-five cycles. This may be effected by a motor-generator set. A polyphase motor taking power equally from each phase of the high-frequency circuit may drive an alternator, either single-phase or polyphase for furnishing current to the single-phase railway. The converting outfit may be located in the main power-house or in a substation, as may be found most convenient.

THE FIELD FOR SINGLE-PHASE RAILWAYS.

The development of a new and more efficient method for accomplishing a given result often leads on and opens new fields which had not been commercially practicable before. Such is the case with the single-phase railway. The direct-current interurban railway has its limitations. If a region be sparsely settled the available traffic will not show a profit on the cost of circuits and rotary converter substations. There is a material reduction in the investment and operating expense incident to the single-phase railway that will enable it to be built and operated with a profit in cases where the traffic would not support a rotary converter system.

On the other hand, in heavy service the direct current has not made much headway, being handicapped by the heavy cost of substations and of conductors. Heavy and relatively infrequent trains are the hardest loads for substations. For example, if substations be eight miles apart each will supply eight miles of track. A train running forty miles per hour will receive current from a given substation for twelve minutes. In order that a substation may be continuously supplying current to trains in one direction they must have a headway of twelve minutes. If they be an hour apart the current from each substation is used but one-fifth of the time. Trains in two directions will double the substation output, but as the peak load is considerable when two trains pass near a substation the load-factor is extremely low. It is evident that some of the substations could be omitted and those remaining would have ample capacity to supply the requisite current at a high load-factor, provided the current can be efficiently and economically transmitted from substation to car. But the cost of conductors for direct current at 500 or 600 volts when substations placed further apart soon becomes prohibitive; hence, the otherwise superfluous number of substations with apparatus running with low load-factor are necessary. But the single-phase equipment by reducing the size of conductors enables the substations to be more widely separated. This possibility in the reduction in the number of substations and in the aggregate capacity of substation equipment, as well as the elimination of rotary converters and their attendants makes practicable the operation of long-distance roads which could be equipped for direct current only at an excessive cost.

These examples show that the high-voltage trolley brings into commercial practicability a class of long-distance, infrequent, heavy service for both passenger and freight, which has not been reached by the direct current.

The single-phase system therefore decreases the cost of installation and operation for the kind of interurban service which has been successfully developed by the direct current, and it extends the field of commercial operation to include, on the one hand, rural roads with relatively light traffic, and on the other, a heavy, infrequent, multiple-unit or locomotive service for passenger or for freight approximating steam railway conditions.

SINGLE-PHASE RAILWAYS IN OPERATION.

The single-phase railway which shows the most extensive operation as measured in car-miles is that of the Indianapolis & Cincinnati Traction Company. Operation was begun over a short length of track January 1, and on April 1 thirty-seven miles were covered. Since July 1 a regular schedule has been maintained over forty-one miles, thirty-seven miles of which are under alternating-current trolley and the remaining four miles are under direct-current trolley in the city of Indianapolis. The company has ten cars, each equipped with four seventy-five-horse-power motors. A maximum speed of sixty and sixty-five miles per hour is secured and the cars are not only the heaviest but they operate upon the fastest schedule of any of the numerous suburban roads, radiating from Indianapolis. Some defects have developed in the equipment, which, however, have been incidental in character. It was found that the natural ventilation under the car was insufficient for the transformer and a ventilating motor was added. A weak point developed in the armature insulation when the cars which had been running for some time by alternating current were first run regularly over the direct-current lines into Indianapolis. One feature of the new condition was the opening of the circuit with four motors in series, the motors having laminated fields which give greater field discharge than solid poles. The remedy was obviously the strengthening of the insulation. This brings out the interesting fact that operation on alternating current at 3,300 volts with an intervening transformer is less severe upon the motor than operation on direct current at 500 volts. Experience showed wherein the control apparatus, suitable for both alternating and direct current, could be simplified and the apparatus reduced in quantity. The result is a control system which is relatively simple and compact, although suitable for operation interchangeably between

alternating current and direct current. The best verdict upon the working of the system has been given by the operating company. It is found in the contracts which have been placed for extending the present line a distance of sixteen miles; also in extending the single-phase operation to the Shelbyville line, both to the twenty-six miles which have been operated by direct current and for a twenty-mile extension. The length of track is therefore to be increased from about forty to 100 miles; the number of cars will be double the present number and all equipments will be similar. It is significant that a company which has been operating two substantially similar suburban lines, one by single-phase current and the other by direct current, should see fit to throw out the direct current and substitute single-phase alternating current. It may be noted that this course was taken, although the reverse was easily possible, as provision was made in the original contract for the single-phase apparatus by which it would be exchanged for direct-current equipments if its operation proved unsatisfactory.

Other single-phase roads which are operating Westinghouse equipments show a variety of conditions, some having exceptionally sharp curves and steep grades. On the road between Derry and Latrobe, in Pennsylvania, thirty-ton cars are started on a ten-per-cent grade. The cars have platform controllers and are equipped with four fifty-horse-power motors. In some cases the initial operation has been handicapped on account of incompleteness, or through the use of temporary apparatus either in the power-house or on the car. In its fundamental elements, however, the operation is proving perfectly satisfactory.

SOME NEW ROADS.

The extension to long distances will soon be shown in the carrying out of the contract which has been closed by the Spokane & Inland Railway Company for 150 miles of railway running south from Spokane, Wash. The equipment will consist of fifteen motor passenger cars, each with four 100-horse-power motors; six motor freight cars, each with four 150-horse-power motors, and six forty-ton freight locomotives. The engineer of this road has been intimately connected with the installation and operation of the single-phase road at Indianapolis.

The most notable recent event in electric traction is the purchase of Westinghouse single-phase locomotives by the New York, New Haven & Hartford Railroad Company. The passenger trains on this road which enter Grand Central station in New York run over the tracks of the New York Central Railroad for about twelve miles. As steam locomotives can not enter the new terminal station and as the New York Central is equipping its track for direct current it is imperative that the New Haven trains be handled over twelve miles by direct-current power. Instead of changing from electric to steam locomotives for all local and through trains, at the end of twelve miles it was decided to extend the electrification and to do it, not by extending the direct current, but by changing to alternating current. The single-phase locomotives will be designed so that they may operate interchangeably from direct current or from single-phase alternating current.

The adoption of the single-phase system by one of the leading railroads of the country for its heavy and important passenger service is all the more noticeable, first, because its officials are already familiar with electric traction matters through the operation of many important city and interurban railways in New England, and second, because the obvious thing to have done would have been to follow the example of the New York Central by adopting direct-current locomotives. Probably this is the turning point, and the coming electrification of heavy railways will follow the conspicuous example set by the New York, New Haven & Hartford Railroad Company by adopting the single-phase system.

American Telephone and Telegraph Appointments.

The following appointments have been announced, to take effect October 1:

H. S. Brooks, formerly district superintendent first district, to assist general superintendent, with headquarters in New York city.

Charles H. Fuller, formerly manager, Boston, Mass., district superintendent first district, vice Brooks; headquarters in New York city.

Henry McDonald, manager, Boston, Mass., vice Fuller.

J. L. Van Meter, superintendent of traffic at the head of the bureau of traffic; headquarters in New York city.

Experiments with Wireless Telegraphy for Communicating with Trains.

The Prussian state railway authorities have been conducting experiments with wireless telegraphy for signaling to moving trains. These tests began two years ago on the Berlin-Zossen military railroad, and have been continued up to the present time. Tests which were conducted a few weeks ago have shown that communication can be maintained, by means of wireless telegraphy, between a moving train and stations along the line. The movements of the train were directed in this way, and special telegrams were sent whenever desired.

Measuring the Resistance of Electrolytes in a Metal Refinery.

TO THE EDITOR OF THE ELECTRICAL REVIEW:

In the report of the discussion of Mr. Threlfall's paper (page 512, current issue ELECTRICAL REVIEW) read at the recent meeting of the American Electrochemical Society, my remarks have been misquoted and misinterpreted. The sense of what I said was: "as high a degree of accuracy as is obtainable with this method is not necessary in the routine work of a metal refinery, where quick volumetric methods are used for determining the composition of the electrolyte. An apparatus similar to that which Professor Burgess has described has its advantages in that it is simple in construction and a curve can be plotted in less than half an hour." The resistance measurements of the solutions are used in connection with their chemical composition, and the methods used for determining the composition are not accurate to within one-tenth of one per cent. A rapid method such as that described by Professor Burgess is sufficiently exact for practical purposes.

FRANK D. EASTERBROOKS.

October 3.

[We regret that our condensed report of Mr. Easterbrooks's remarks appears misleading, and are pleased to publish this letter.—ED.]

Ninth Annual Meeting of the Railway Signal Association.

The ninth annual meeting of the Railway Signal Association will be held in the assembly hall connected with the International and Cataract hotels, Niagara Falls, N. Y. Sessions will be held as follows:

October 10, at 10 A. M., 2 P. M. and 7.30 P. M.

October 11, at 8.30 A. M. and 2 P. M.

October 12, at 8.30 A. M. and 1 P. M.

The headquarters of the association will be at the International Hotel.

A special room will be provided for displaying such articles and appliances as may be deemed desirable to submit to members. The room will be provided by the secretary, and can be occupied at any time after 10 A. M., October 10, and until 6 P. M., October 12.

The following papers will be presented: "Some Observations on Signal Lenses," Charles H. Williams, M. D.; "The Use of Storage Batteries for All Electric and Other Signal Devices," by Edward L. Adams; "Cost of Stopping Trains Compared with the Cost of Maintenance, Operation and Inspection of Interlocking Plants," by J. A. Peabody; "Second Report of Comparative Tests of Roundels from an Ophthalmologist's Standpoint," by Nelson M. Black, M. D. There will also be committee reports from the various standing committees.

Reviews of Current Engineering and Scientific Literature.

A New Gas Turbine.

A proposed form of gas turbine has been patented recently in England. A description and drawings of this device are given here. It is of the impulse type, the gases passing through expanding nozzles, then impinging upon the blades of the running part. In order to obtain a practical speed of this part, and to use the gases efficiently, they are returned several times to the wheel. The gas first passes through a nozzle, striking the blades of the wheel from one side, and upon issuing at the far side is guided by a second channel ending in a nozzle so as to impinge upon the blades of a second wheel. Issuing again from the far side of this wheel they are caught in a second guiding channel and returned again to the wheel; thence through a third channel and back to the first wheel, and so on, each succeeding channel and its nozzle being larger than the one preceding, to allow for the expansion of the gas. Since the temperature of the working fluid is very high, the gas channels are surrounded by water jackets for cooling them, and the running part made fairly large, so that the blades will be in contact with the hot gases during a comparatively small part of each revolution, the remaining time being available for cooling. When employed with gas, two pumps are used—one for compressing the gas, and the other for compressing the air. The discharges in these pumps are arranged so as to mingle the two gases in a combustion chamber. When a liquid fuel is employed it may be sprayed or vaporized, and used as a gas.—*Abstracted from the Mechanical Engineer (London), September 9.*

Ferro-Alloys.

The uses of the ferro-alloys in the iron industry are here considered by Mr. A. J. Rossi. As is well known, certain of the rarer metals, such as vanadium, molybdenum and tungsten, are valuable for the production of high-speed tool steel, but our supply of these metals is not likely to last longer than the present generation. For this reason a similar use of titanium is important, since this metal is to be found abundantly. The difficulty encountered heretofore in producing titanium alloys has been the high temperature required in the furnace, but this high temperature is now obtainable in the electric furnace, and the alloys may be produced at not too great cost. Whenever titaniferous iron ores—that is, magnetite or other iron ores containing titanium oxide—have been smelted in a blast furnace, the pig iron has been found to contain either no titanium at all or only a very few hundredths per cent, and in these cases it has mattered nothing whether the ore smelted contained one per cent of titanic oxide or forty-five per cent of it, or more. The pig iron, however, possesses remarkable toughness. This suggested the idea that an alloy of iron and titanium containing a greater percentage of titanium could be prepared electrically, and would be of much value. Whenever a metallic oxide is reduced by carbon, the product is likely to contain more or less carbon, and if the presence of this carbon is objectionable, it is difficult to remove it. This difficulty is also overcome in the electric furnace, for if carbon remains in the metal it is necessary only to add some additional oxide of the metal in order to drive off the carbon. The furnace first used for this purpose was of the Siemens type, and consists of an iron shell lined with graphitic material. The bottom of the shell formed one electrode. Within the interior a carbon electrode was introduced, which could be moved up and down at will. Current was supplied at voltages varying from 20 to 100. The material to be reduced was placed within the furnace, and an arc struck in the usual way. This material consisted of titaniferous iron ores and carbon in some form. As the reduction took place and slags were formed, they could be drawn off through one opening, the alloy through another, and additional ore introduced at the top. Mr. Rossi has made a good deal of ferro-titanium in this way, certain alloys containing from five to eight per cent of carbon and ten to thirty-five per cent of titanium. The furnace also produced ferro-chromium containing sixty-eight per cent to seventy-eight per cent of chromium. The greater part of the carbon is easily got rid of, though the last one or two per cent is more difficult to drive off. A new method of producing these alloys is made available by the invention of the Goldschmidt powdered aluminum process; but powdered aluminum is rather expensive, and to avoid this Mr. Rossi has found that a bath of molten aluminum will act just as well. The bath of aluminum is kept liquid by an electric current, and the products to be reduced are thrown upon the surface. Reaction sets in at once and goes on quietly without explosion. It can be moderated or stopped by regulating the current flowing. The process can be made continuous by adding additional aluminum and ore, the reduced material being drawn off as it is formed. In this way Mr. Rossi has been able to make ferro-titanium practically free from carbon, containing from ten to seventy-five per cent, and more, of titanium. The product contains a small percentage of aluminum, but if this is objectionable it can be removed easily by adding an excess of oxides at the end of the operation.—*Abstracted from Cassier's Magazine (New York), September.*

The Testing of High-Tension Insulating Materials.

The author of this article, Mr. C. Kinsbrunner, finding it necessary to obtain accurate data on the dielectric strength of commercial insulating materials, upon investigation was disappointed at the divergence of the experimental results, as published by various authors. Differences of from 150 to 250 per cent with materials of the same description were not rare. While many insulating materials differ considerably in quality, others have become standard in this respect, so that the differences in the experimental results must be looked for elsewhere. As long as such uncertainty prevails the designer must protect himself by using a large factor of safety, whereas more consistent results would enable this to be reduced, and at the same time decrease the cost of the machine. The author therefore determined to make a thorough study of insulating materials himself. For this purpose he obtained the use of the well-equipped, high-tension laboratories of the Municipal School of Technology, of Manchester, England. His investigation is divided into four parts. It was first necessary to decide upon the conditions for testing insulating materials; next, to determine the specific dielectric strength of the various materials; third, to determine the ratio between thickness and dielectric strength; fourth, to find what effect lamination of insulating materials has upon the dielectric strength. This article deals with the first part of the work only. The method of testing was that usually adopted, a high-tension transformer being used to break down the samples of insulation. These samples were placed between

pairs of specially shaped electrodes; then in a small box mounted on insulators. They were subjected to definite frequencies. Voltages were measured by four instruments: a vertical electrostatic balance was used for voltages up to 4,000; for voltages between 3,000 and 6,000, and 5,000 and 10,000, two electrostatic voltmeters were employed; for voltages between 10,000 and 100,000 a special voltmeter, constructed as a vertical electrostatic balance, was made use of. These instruments, as far as can be ascertained, read accurately within two or three per cent. The wave-form of the dynamo which furnished testing current was determined by means of an oscillograph and found to be nearly sinusoidal. The first experiments were made to determine the effect of the shape of the electrode. Six electrodes were employed: one pointed at an angle of fifteen degrees; three spherical, having different radii; and two flat, having different diameters. Experiments made to determine the influence of pressure on the electrode showed that for all electrodes the disruptive voltage is independent of the pressure on the electrode, provided this pressure exceeds about a quarter of a kilogramme per square centimetre. The effect of continued application was also investigated for the different electrodes. Curves of these results are shown. From them it is concluded that, in order to obtain the actual disruptive voltage for an insulating material, it is essential that it should be tested with a flat electrode. As the breaking down point does not depend on the size of the electrode employed, it is rather advantageous to employ a smaller electrode, considering that the time constant increases with the size of the electrode. The length of time for which the material should be subjected to a voltage varies with the area of the electrode employed, and the material. Active disruptive voltage may be defined as that maximum voltage which the material will stand for a time somewhat in excess of the time constant. From experiments made with different thicknesses of press-board, it was found that the time constant is larger the thicker the material. Insulating material will withstand a voltage for a short time which is considerably in excess of that which it would stand for any length of time, but the point is soon reached when a further application will not break down the insulation. The time required to reach this point is called the time constant. It varied in these experiments from a minute and a half for the smaller electrodes to four minutes for the flat ones. It was decided that insulating materials should not be dried before testing. Not only should the tests be conducted under usual conditions, but it is very probable that, due to variations in temperature during the manufacture of the materials, the percentage of moisture which they contain does not vary greatly. Materials of various kinds were tested and gave corresponding results, those of moderate strength showing a time constant not exceeding half an hour. For this reason it is suggested that the disruptive voltage be defined as that maximum voltage which the material will stand for about half an hour. The procedure for testing insulating materials should therefore be as follows: the voltage should first be raised to the sparking point in small steps, at intervals of about twenty seconds. A new piece should then be taken, and the voltage be reduced to about seventy or eighty per cent of the sparking voltage. The time which passes between the application of this reduced voltage and the breakdown must be measured carefully. Should this time be less than the time constant, another test must be made with a somewhat lower voltage. If, on the other hand, the material withstands the voltage for a time which is longer than the time constant, the test must be repeated with an increased voltage. It is advisable that a new piece of material be used for each of these tests. The author has adopted these conditions for all tests made on insulating materials, and has found that they lead to very regular and reliable results.—*Abstracted from the Electrician (London), September 8 and 15.*

Measurement of the Slip of Induction Motors.

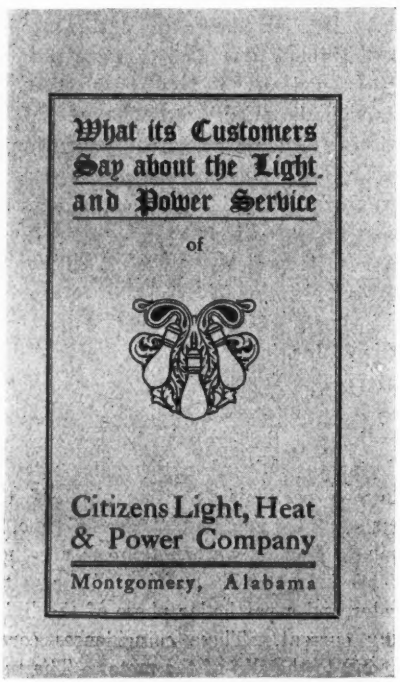
Several improvements of certain methods of measuring the slip of induction motors are here described by M. A. Tian, some of them being very pretty and simple. The slip of an induction motor may be determined in percentages by obtaining the ratio between the currents flowing in the primary and the secondary parts. The frequency of the latter may be measured by a voltmeter or recorded by a simple Morse printing receiver. Stroboscopic methods, which depend for their operation upon the successive illumination of a disc on the rotating part of the motor by an electric lamp supplied from the same circuit, have a disadvantage, in that the periods of illumination last too long. This may be improved by lighting the disc with an alternating-current lamp, in whose circuit an electrolytic interrupter is placed; but this method has a disadvantage because it is difficult to keep the arc burning. It is better to use an incandescent lamp. This lamp should be of small candle-power and have a thin filament, so as to cool off rapidly. A better effect is obtained if the light be supplied from a piece of platinum wire brought to incandescence in the open air. Another method makes use of the rotation of the plane of polarization of a beam of light by a magnetic field. An alternating-current magnet is excited from the same source of supply as the motor. A beam of light from an incandescent lamp or any other source, lighted from the same circuit, is passed through a glass tube filled with some material able to produce magnetic rotation. At each end of this tube is placed a Nicols prism, which are then turned over so as to allow the source of light to be used through them. The magnet is excited, and when viewing the source through the prisms, it is seen to pulsate with a frequency twice that of the supply circuit. By turning one of the prisms one way or the other, half of these pulsations are cut out, and the source of light appears to pulsate with the frequency of the supply circuit. Now, by arranging the supply of light so that it does not shine directly through the prisms, but is reflected from a mirror placed on the shaft of the motor, and set at an angle to the axis, the light can be seen through the prisms only when the motor rotor is in one particular position; and if the magnet be excited at the same time, it can be seen only when there is a coincidence between this position of the motor rotor and a particular phase of the lighting current. These coincidences correspond to the slip of the motor. The tube within the magnet may be filled with carbon bisulphide or a saturated solution of the double iodide of mercury. It is better to illuminate the mirror from a screen lighted by the lamp rather than to throw an image of the lamp itself through the prisms. If Nicols prisms are not at hand, they can be replaced by small pieces of glass properly oriented. A satisfactory rotation of the plane of polarization can be obtained in the second liquid mentioned above with an excitation of 2,500 ampere-turns and a glass tube ten centimetres long.—*Translated and abstracted from L'Éclairage Électrique (Paris), September 2.*

Methods of Getting New Business.

A department devoted to the commercial development of Central Stations. Managers are invited to contribute suggestions for methods of increasing the demand for electric service.

Last June Mr. C. W. Lee, speaking before the National Electric Light Association, at its twenty-eighth convention at Denver, Col., made the following remarks:

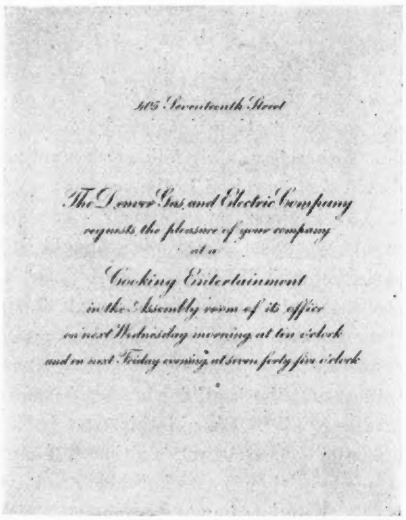
"I am familiar with the methods of a lighting company covering a well-populated but scattered territory, which, at the beginning of 1904, had less than fifty signs connected. This company adopted the free sign proposition, gave away two standard types of sign, both of which were changeable, and at the beginning of 1905 had over 450 connected, containing



COVER PAGE OF BOOKLET DISTRIBUTED BY CITIZENS' HEAT AND POWER COMPANY.

a total of 29,749 four-candle-power lamps, returning an annual revenue of $59,130.48. This company charged off the first year the cost of constructing signs of changeable letters, as well as all erecting and connecting cost, together with twenty per cent depreciation on the sign, five per cent depreciation on the station, line, meter and transformer investment. Charging the current used at cost, with lamp renewals and maintenance, it earned from ten to fifty per cent on the investment for each sign and its pro rata station and line cost.

"With a view to further increasing the sign business, this same company has recently placed in operation a plan whereby


475 Seventeenth Street
The Denver Gas and Electric Company
requests the pleasure of your company
at a
Cooking Entertainment
in the Assembly room of its office
on next Wednesday morning at ten o'clock
and on next Friday evening at seven forty five o'clock

INVITATION ISSUED BY THE DENVER GAS AND ELECTRIC COMPANY.

the greater portion of its sign lighting will be entirely removed from its peak during the months when the peak must be considered. Free signs on a flat rate for certain stipulated hours each night is the nucleus of this plan.

"The meter has been a formidable obstacle in the upbuilding of the sign business. In most cities and towns the early closing movement is in vogue, and this makes the flat rate welcome, as many merchants are obliged to leave their signs and windows in darkness, rather than go to the expense of employing a watchman to cut their lights out at a certain hour."

Last winter a number of department stores throughout the country were supplied with electric heating and cooking utensils by some of the prominent manufacturers of this apparatus, and demonstrations were given daily, resulting in quite an extensive sale of these utilities. Many of the central station companies have adopted this plan of demonstration, and have installed in their main offices domestic apparatus which attracted considerable attention to the use of the electric current. The Denver Gas and Electric Company, Denver, Col., made a practice of having a demonstration of this nature at intervals, and an invitation issued a short time ago is reproduced herewith. This invitation is a copper-plate engraving, and was presented to a selected list with all the formality of a very particular occasion.

The Citizens' Electric Light, Heat and Power Company, of Montgomery, Ala., published quite recently a booklet which it distributed freely within its territory. The purposes of the company are set forth, and a number of testimonials from business men and residenters are presented to prospective consumers. This booklet contains twelve pages, and is bound in a tough cover three and one-half inches by six inches.

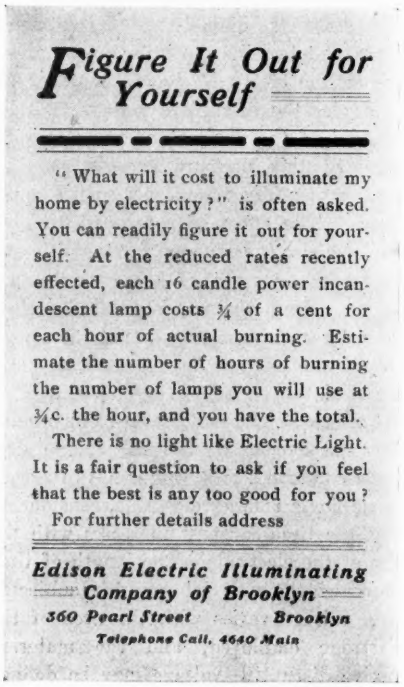


Figure It Out for Yourself
"What will it cost to illuminate my home by electricity?" is often asked. You can readily figure it out for yourself. At the reduced rates recently effected, each 16 candle power incandescent lamp costs ¼ of a cent for each hour of actual burning. Estimate the number of hours of burning the number of lamps you will use at ¼c. the hour, and you have the total.
There is no light like Electric Light. It is a fair question to ask if you feel that the best is any too good for you?
For further details address
Edison Electric Illuminating Company of Brooklyn
360 Pearl Street Brooklyn
Telephone Call, 4640 Main

FLIER DISTRIBUTED BY THE EDISON ELECTRIC ILLUMINATING COMPANY OF BROOKLYN.

The Edison Electric Illuminating Company, Brooklyn, N. Y., has been active in canvassing its territory, not only by personal solicitation, but with a systematic follow-up system of mailing-cards. A card which has attracted considerable attention from business men along the main thoroughfares is reproduced herewith. This is printed in black on a yellow leaflet three inches by five inches.

INDUSTRIAL SECTION.

ILLUSTRATED DESCRIPTIONS OF NEW AND STANDARD ELECTRICAL AND MECHANICAL APPARATUS.

Standard and Miniature Enclosed Arc Lamps.

The American Arc Lamp Company, Kalamazoo, Mich., is now established in its new and well-equipped factory. This company succeeded to the business of the Lea Electric Manufacturing Company, formerly of Elwood, Ind., and has devoted almost a year to the further improvement of the lamp formerly made by the Lea company, which had been in practical use for over ten years. The company makes a specialty of direct-current multiple lamps for use in shops, factories, stores and offices, the lamps being very simple in construction and consisting of five parts

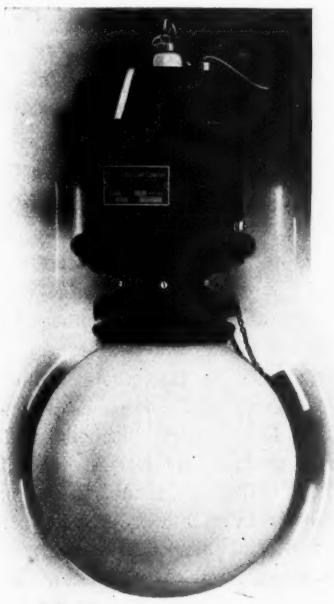


FIG. 1.—STANDARD SHOP AND FACTORY LAMP, COMPLETE.

—the magnet coil, lever, dashpot, clutch and resistance coil.

All the lamps are equipped with a magnet coil which is practically indestructible, and the company states that the lamp may remain on a dead short-circuit many hours without damage to the coil. The lever is constructed of steel, and is strong and light. It connects the action of the magnet coil with the dashpot, to which is also attached the clutch rod.

The dashpot plunger is made of self-lubricating graphite, giving positive and easy action.

The clutch is constructed on the toggle principle, ensuring reliability in feeding, and precluding the possibility of the carbon slipping. The resistance coil is wound on two solid ventilated porcelain cores, and can not short-circuit. The lamps are provided with a new design of switch which can not short-circuit or arc

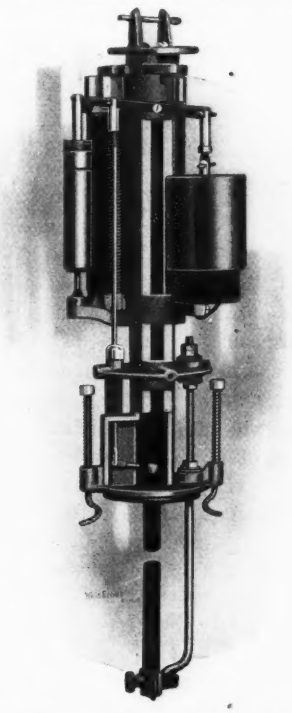


FIG. 2.—STANDARD LAMP, WITHOUT COVERS. FRAME COMPLETE.

across. The switch is quick and positive in action, and is unaffected by vibration When it is opened by the ordinary movement of the lever it remains open locked in position, and no amount of pressure will cause it to fall back or short-circuit. When closed it remains locked in position, forming a perfect contact. The upper carbon-holder has a copper contact, and is entirely enclosed in a metal guide tube. The lower carbon-holder is a single rod holding the lower carbon with a detachable holder. The lamps are easily trimmed. The detachable holder is a new feature by which it is possible to replace a burned-out holder without disturbing the insulation of the rod. The lamps are made to cut themselves out when the carbons are consumed, and will invariably do so when properly trimmed.

All lamps are provided with hinged, swinging covers. These automatically catch when open, and remain in place entirely out of the way, making every part accessible. When closed they snap tightly together. The inner globe is held from above by two fingers, allowing its removal while hot, and prevents shadows. The lamps can be provided with chimney swings if preferred. The outer globe is held by a metal ring which catches into the base ring by a single pawl. While removed, the globe is held suspended entirely out of the way by a brass safety chain. The same metal ring is used for shades.

Fig. 1 shows the standard direct-current shop lamp with covers closed. This lamp is twenty-two inches long and

FIG. 3.—LOWER CARBON HOLDER.

weighs twenty-four and one-half pounds complete. The size of carbon is one-half inch by twelve inches. The lamp is furnished with cast-iron covers and finished in plain black, japanned, with all exposed parts in polished nickel. The apparatus is dustproof, and is built to stand rough usage. It is interchangeable and made to burn singly across 110 or 220-volt direct-current circuits.

Fig. 2 illustrates the standard lamp without covers, showing the frame. This illustrates the working of the clutch on the upper carbon. The frame is cast in one piece with a hollow tube in the centre, enclosing the upper carbon and clutch. The construction and action of the lamp are very simple.

Fig. 3 shows the lower carbon-holder.

New Type Induction Motors.

The National Electric Company, Milwaukee, Wis., is placing on the market a new type of induction motor. These machines are of extremely heavy and substantial construction, and they may be operated from the floor, side wall or ceiling by changing the brackets which carry the bearings. Owing to the high speeds

NEW TYPE INDUCTION MOTOR.

at which the machines operate, and the small space between stator and rotor, a very heavy shaft is used, while the bearings are of large area, eliminating, as much as possible, any variation in the air-gap.

The frame is made of cast iron, into which are assembled the laminations. The windings are all form-wound by automatic machinery, and between each coil air space is provided to take care of the heating. Ventilation has also been given careful consideration, there being numerous openings provided in the frame; and there are also ventilating spaces between the laminations.

The rotor is of the squirrel-cage type, with copper rods inserted in the slots. This is built up of laminations of mild steel, assembled on a spider and held firmly in place by end-plates.

All bearings are self-oiling and have wearing surfaces of ample proportions.

An autostarter is furnished with the squirrel-cage type, consisting of transformers connected across the line, with voltage taps suitable for starting the motor under different conditions of load. A switch of suitable construction is provided for throwing the motor from one voltage to another. All of this apparatus is immersed in a tank of oil, which makes it sufficiently reliable to operate at high voltages, and which takes care of any heating due to starting under heavy torque.

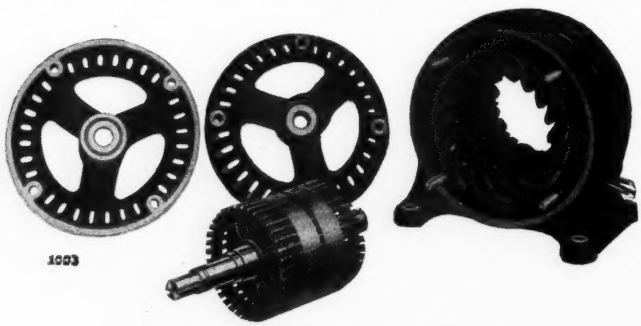
An Improved Carbon Brush.

The National Carbon Company, Cleveland, Ohio, has placed on the market an improvement in carbon brushes, designated as an expansion connection brush.

In this brush a number of distinguishing features are embodied. The device consists of a carbon brush of any size, having a hole drilled into it penetrating about one-half of the length of the brush. A piece of plaited flexible wire, terminating in a cable shoe, is unraveled at the end opposite to the cable shoe, and this miniature wire net is formed cylindrically around a little brass sleeve. This sleeve is of the same length as the hole in the carbon brush, and is slotted over two-thirds of its length. The slot is tapered so that the closing screw fitting into the sleeve is forced into a tapering hole. The resistance with which the screw meets on account of this taper is overcome by the expansion of the sleeve, so that the whole appliance acts as a wedge when the screw is inserted, making a close and rigid contact between the flexible wire and the interior of the brush. This is increased through expansion of the metallic parts, should the brush become heated while in use.

This flexible connection is easily detached and can be connected to a new brush by means of a screw-driver, obviating the necessity of attaching by means of the soldering process.

The connection is so arranged that the distance between the commutator surface and the terminal connection is reduced to a minimum, thereby reducing the carbon resistance between these points, resulting in obtaining a higher efficiency and a lower loss between the commutator surface and the end of the connection.



PARTS OF NEW TYPE INDUCTION MOTOR.

Consolidation of Water-Tube Boiler Interests.

A consolidation of great interest to the engineering world has been consummated through the amalgamation of the water-tube boiler business of the Aultman & Taylor Machinery Company, of Mansfield, Ohio, and the Stirling Company, of Barberton, Ohio, as a result of which the Stirling Consolidated Boiler Company will be organized with a capital of $4,500,000. The position of the new company will be unique, in that it will be able to supply to the trade practically every type of water-tube boiler; for, in addition to manufacturing boilers of the Stirling and Cahall horizontal and vertical types, it will shortly take up and place upon the market an improved water-tube boiler of the water-leg type.

It is probable that the consolidation will be one of organization as well as of plant. The export business will be handled through the foreign connections of the Stirling Company, in its offices at Johannesburg, South Africa; Havana, Cuba; Buenos Aires, Argentina; Yokohama, Japan, and the Hawaiian Islands, as well as through its stock connection with the Stirling Company, Limited, of Edinburgh, which is a prominent factor in the water-tube boiler business of Great Britain and the Continent.

The Stirling Company was organized in 1890, and in 1898 established its marine department, securing control of the United States patent on the Niclausse and Yarrow boilers. Its growth is illustrated in an increase of sales in eight years of nearly 800 per cent.

The development of the Cahall sales department of the Aultman & Taylor Machinery Company has formed an equally important part of recent American industrial history. The new company thus starts with an enviable prestige, and with every facility for manufacturing and selling. The general offices will be at 111 Broadway, New York city.

Interior Automatic Exchange Telephones.

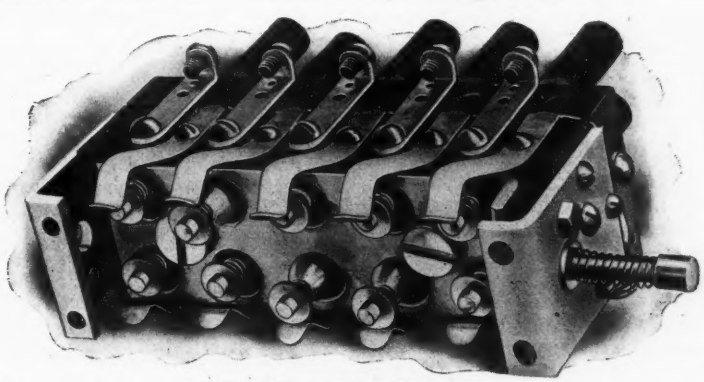
The Connecticut Telephone and Electric Company, Meriden, Ct., has placed

INTERIOR AUTOMATIC EXCHANGE TELEPHONE.

on the market an intercommunicating telephone for interior service. This instrument can be connected to the exchange, and is stated by the manufacturer to be absolutely non-interfering.

One of the valuable features is the new non-interfering exchange trunk button, this device being so arranged that it cuts the telephone from the interior system to the trunk wires, so that there is no chance for interfering. With this telephone it is possible to call direct to any point in the system with the receiver on or off the hook. The buttons are automatically restored when the receiver is returned to the hook, and the telephone is also cut off the line. It is also possible to call any number of departments together and hold a joint conversation.

All connections in these instruments are



NEW MECHANICAL SWITCH.

mounted on hard rubber, and all contacts are rubbing and very positive.

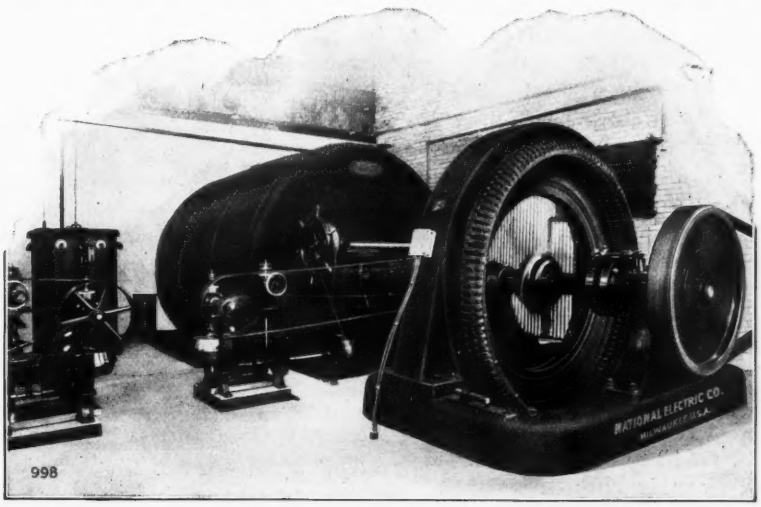
The plate of this instrument does not enter into the talking circuit, and is made of steel, doing away with the wear and tear which may obtain with brass.

This telephone is being adopted by some of the largest exchanges, and it is particularly adaptable for common battery exchange service.

The batteries for the system are centrally located.

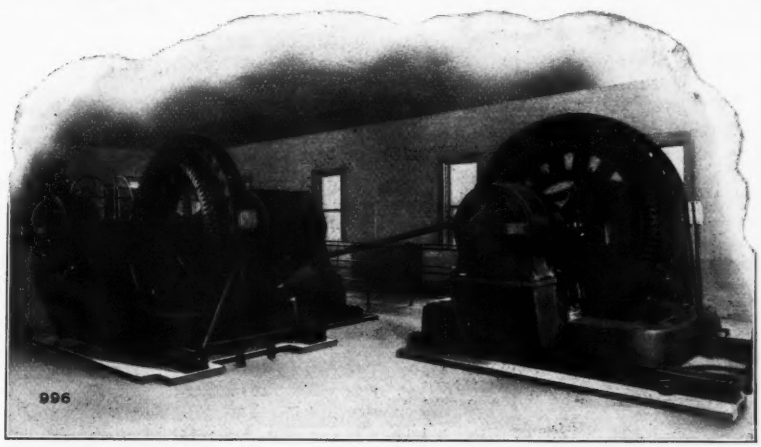
The Stillwater, Minn., Gas and Electric Company.

The Western Gas and Investment Company, with headquarters in Chicago,



RIVERDALE, WIS., PLANT OF THE WESTERN GAS AND IMPROVEMENT COMPANY.

and owner and operator of a number of electric lighting and gas plants throughout the country, acquired some time ago the property of the Stillwater (Minn.) Gas and Electric Company. In conjunction therewith it also acquired water powers on the Apple river in Wisconsin—one at Somerset, Wis., approximately twelve miles from Stillwater; the second one at Riverdale, Wis., approximately fourteen miles from Stillwater.



SOMERSET, WIS., PLANT OF THE WESTERN GAS AND IMPROVEMENT COMPANY.

At Somerset the water power had been previously developed and there was in operation an electric plant supplying current to a number of surrounding towns. The electric portion of this plant has been entirely remodeled and it now has in operation two 250-kilowatt, 450-revolutions-per-minute, 2,300-volt, three-phase, sixty-cycle, belted-type, alternating-cur-

rent generators with direct-connected exciters.

At Riverdale the company has constructed a concrete dam with power-house and has located therein two 250-kilowatt, 200-revolutions-per-minute, 2,300-volt, three-phase, sixty-cycle generators direct-coupled to water-wheels.

In each of the above stations are located three 200-kilowatt, oil-insulated, water-cooled transformers, which convert the generator voltage of 2,300 volts to 15,000 volts. The two stations, Riverdale and Somerset, which are located two and a half miles apart, are run in multiple with each other and the combined output is transmitted to Stillwater, Minn., where it is reduced by means of three 400-kilowatt, oil-insulated, water-cooled transformers for use in commercial and city lighting, and also for furnishing a large amount of current for power purposes.

The generators and transformers in each of the stations were manufactured and installed by the National Electric Company, of Milwaukee, Wis., and the water-wheels in the Riverdale station were furnished by S. Morgan Smith, of York, Pa.

The plant has now been in successful operation for some time and is one of the best-designed plants now in the Northwest. Mr. R. S. Feurtado, who is the engineer of the Western Gas and Investment Company, has given the design of this plant his entire attention and its successful operation is an evidence of satisfactory supervision.

The National X-Ray Reflector Company.

The National X-Ray Reflector Company is moving into enlarged quarters at 126 Franklin street, Chicago, Ill., where it will have increased facilities for handling its growing business. The company has added to its regular line some novel and effective lighting specialties. These specialties will be supplied to the trade after October 25. They include ceiling rosettes, both in convex and concave shapes; a new seven-inch and ten-inch corrugated cone; two new half-shades, which are especially ornamental and effective; and a fourteen-inch sectionable and adjustable corrugated sterling-silver-plated, glass-trough reflector for store-window and picture lighting. This trough reflector is expected to revolutionize store-window lighting, as it is easily adjusted to any size of window and can be operated at a considerable reduction in the cost of current, and with a large increase in illuminating effect.

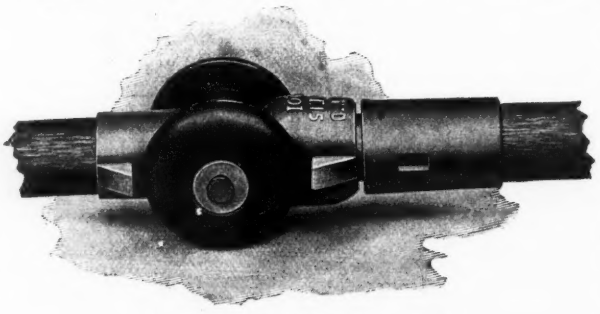
The X-ray reflector is an exclusive departure from ordinary forms of window lighting. It is sterling-silver-plated and is not affected by heat or cold. The silver plate is backed with enamel that expands and contracts evenly with the glass. This cover is so adapted to the silver-plating as to act in harmony without discoloration of the silver.

The ceiling rosettes embody a new idea in the lighting of decorated ceilings. In order to avoid throwing shadows on the decorations of ceilings, the rosettes are made both concave and convex.

Automatic Wheel Conduit Rods.

The Diamond Expansion Bolt Company, 9-15 Murray street, New York city, has placed on the market an automatic wheel conduit rod designated as the "Go-Esy." This is shown in the accompanying illustration. These rods are simple in construction, and can be coupled or uncoupled instantly. It is claimed that the rods will not buckle or form a zigzag line when pushed through the conduit, as they are as rigid as solid joint rods when used in this way. Special provision is made so that they are flexible when pulled, allowing considerable variance when crossing a manhole, making it easy to enter another duct out of line with the preceding duct, the rods becoming rigid when pushed into the new duct.

The wheels serve to prevent the rods coming into contact with the walls or floor of the duct, eliminating friction and wear, and enabling one man to push a set of rods 600 feet long. The wheels serve also as a duct cleaner, each pair of wheels bringing out a quantity of dirt or mud as they emerge from the duct or pass through the manhole, leaving the duct comparatively clean. In removing the obstruction a hard blow can be struck without injury to the rods. The wheels also ensure a two and one-half-inch duct opening throughout the entire length of the section.



AUTOMATIC WHEEL CONDUIT ROD.

The wheels are so shaped that they will always pass along easily so long as no obstruction narrowing the duct to less than two and one-half inches is encountered. The couplings are made of bronze or malleable iron, the wheels of chilled cast iron, and the rods of the best hickory.

The facility with which the work can be done with these automatic rods makes it possible for a quantity of work to be performed in a very brief time. A record of 20,915 feet by two men in eight hours is claimed for these rods.

Design and Quality in Glassware for Lighting Purposes.

At the recent convention at Atlantic City, N. J., of the American Association of Flint Lime Glass Manufacturers, Mr. A. H. Patterson, of the Phœnix Glass Company, New York city, delivered a brief address entitled "Design and Quality in Glassware for Lighting Purposes." Mr. Patterson sketched the early history of fixture design and the accompanying progress made in the development of glassware to be used with these fixtures. There has been a marked and rapid development and improvement. The new departure had its birth at the time of the Centennial Exhibition in Philadelphia in 1876. At that time a marked and radical change took place in the design and character of lighting fixtures—the substitution on the part of American manufacturers of brass, with its possibilities of graceful forms and superior finish, in place of the massive, heavy, crude and ponderous spelter. A revolution in business also took place—a change from hugeness and coarseness to grace, beauty and effectiveness. With this advancement in the style and finish of the lighting fixtures came the demand upon the manufacturers engaged in making glassware for lighting uses to produce wares of equal character in harmony with the new fixtures. This, indeed, was a new departure. All of the new forms show a longing for, and an effort to produce, something that would be harmonious with the designs of existing interior furnishings and decorations. Following the early efforts of many designers came the creation of the process of etching.

The introduction of incandescent electric lighting gave a wider scope—an enlarged field to work in. With the progress thus brought about, the question came up: "what benefit has this advancement been to the manufacturer?" From the standpoint of achievement, progress and advancement, this question can be answered by the fact that it opened up new and growing possibilities of production and profit—a production that should be profitable because of its high character and use.

CURRENT ELECTRICAL NEWS

DOMESTIC AND EXPORT.

TO INSTALL TELEPHONE SYSTEM IN THE PHILIPPINE ISLANDS—A mortgage for $1,920,000 has been filed by the Philippine Telephone and Telegraph Corporation with the Union Trust Company, of San Francisco, Cal., to secure a bonded indebtedness. There are 1,920 bonds to be issued, of the par value of $1,000 each, to run for fifty years and bear interest at the rate of six per cent. The transaction covers the project of installing a telephone system in the Philippines. The document is signed by Louis Glass, president of the corporation.

INDEPENDENT LONG-DISTANCE TELEPHONE COMPANY—The Independent Long-Distance Telephone Company announces that its line between Decatur, Ill., and Birmingham, Ala., and between Bowling Green, Ky., and Decatur, is almost completed, and that connections will be made at Bowling Green with independent lines of the north and east, which will give Alabama independent companies connections with nine other states. Traffic arrangements are made with the independent exchanges in cities which the lines touch, including Birmingham, and there is a close business agreement between the Long-Distance company and the independent exchanges. The line will be extended to Memphis, Tenn.; Atlanta, Ga., and Mobile, Ala.

HUDSON RIVER TUNNELS OPENED—The second tunnel of the New York & New Jersey Railroad Company was opened last week, thus completing the initial arrangements for the twin tunnels which will connect Jersey City and the borough of Manhattan. On March 12 of last year the company opened the first, or westbound, tube of the twin tunnels. The completion of the undertaking, however, required a parallel tube for eastbound cars. The company is making efforts to have trains running in the system between Manhattan and Jersey City in eighteen months. The New York terminals will be at Astor Place, to connect with the subway, and at Thirty-third street and Sixth avenue. The western terminals are to be, one in Jersey City near the Pavonia Ferry, and one in Hoboken, at the Delaware, Lackawanna & Western station.

KNOXVILLE RAILWAYS AND LIGHT COMPANY—The Knoxville Traction Company and the Knoxville Electric Light and Power Company have been merged into the Knoxville Railways and Light Company. A mortgage for $3,000,000, in favor of the Standard Trust Company, of New York city, has been recorded, and a complete refinancing of the properties is to be undertaken. One hundred and sixty thousand dollars will be set aside to complete improvements under way and in prospect, making a total of $1,000,000 expended in betterments in two years. A reserve of $850,000 is provided to liquidate electric light bonds outstanding, held by the Baltimore Mercantile and Trust Company. An immediate bond issue of $900,000 will be made, and the remainder of the $3,000,000 of bonds will not be floated at the present time.

EXTENSIVE POWER PLANT IN NORTH CAROLINA—Plans are under way for the development of an extensive water plant at Whitney, N. C. The Whitney Company, of which Mr. George I. Whitney is president, is capitalized at $10,000,000, a large proportion of the money invested coming from Pittsburg, Pa. It is planned to have an equipment of some 100,000 horse-power. Fifteen thousand acres of land, covering both sides of the Yadkin river, have been purchased. A dam turning a part of the river from its course through a canal four and one-half miles long is to be built. The contracts necessary for this work have been let, the T. A. Gillespie Company, of Pittsburg, getting the contract for the dam, canal and power-house, while the General Electric Company, Schenectady, N. Y., will install the machinery to transform part of the energy of the river into an initial 40,000 horse-power. There is a drop of 120 feet in the four and one-half miles of the canal, and it is expected that ultimately 120,000 horse-power can be developed. The market for the power includes forty-four towns and cities, with street railways, cotton mills, sawmills and other industries. The plant is to be completed by January, 1907, and it is expected that a large revenue will be available as soon as the plant is ready for operation.

TO CONSTRUCT HIGH-SPEED ELECTRIC LINE—Two companies with $1,000,000 capital each—the Newark & Hackensack River Railroad Company, and the Jersey City & Hackensack River Railroad Company—have been incorporated to construct the high-speed electric line from Newark to Jersey City which will be built by the Public Service Corporation of New Jersey. This line will connect with the tunnel to be constructed from Jersey City, N. J., to City Hall Park, New York city, by the Public Service Corporation and the Metropolitan Securities Company, of New York. The two companies have the same incorporators and directors, and it is expected that later on they will be merged into one company. The incorporators, who are also the directors, are: Thomas C. Barr, J. J. Burleigh, A. B. Carlton, Mark T. Cox, A. R. Kuser, Thomas N. McCarter and Charles A. Sterling. The construction of the New York end of the line and the tunnel under the North river will begin as soon as permission is secured from New York.

TO BUILD A TROLLEY LINE IN HOLLAND—Incorporation papers have been filed for the Holland-American Construction Company, of Rochester, N. Y. The concern is capitalized at $1,000,000. The directors are: Newcomb Carlton, New York city; George C. Smith and Walter D. Updegraff, Pittsburg, Pa.; Joseph K. Lukach, London, England; John N. Beckley, Charles H. Palmer, J. George Kaelber, John F. Alden and George C. Buell, of Rochester, N. Y. Mr. Kaelber has for several months been looking over the ground and securing rights of way and franchises. The company now holds franchises for 115 miles of railroad extending from the German frontier to the North sea. The western terminus of the line, as at present proposed, will be at Wykandosee, a town of less than 5,000 population on the shore of the North sea. The main line will cross Holland in a generally southeast direction to Wykandosee. The road will be about 115 miles in length. From Wykandosee it will run to Zaandam. From Zaandam it will run to Amsterdam. Continuing from Amsterdam it will cross the canal that connects the Rhine with the Zuyder Zee, and enter Utrecht. From Utrecht it will cross the lower Rhine valley to Rhenan. Both freight and passengers will be carried by the proposed road on its main line and branches. It is said that trains will be operated at about sixty miles an hour.

ENGINEERING SOCIETIES.

PROCEEDINGS OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—The proceedings of the American Institute of Electrical Engineers for September contain the discussion on a number of papers presented at the recent Asheville convention, and the discussion on the two papers presented at the May meeting in New York city.

PHILADELPHIA SECTION OF THE AMERICAN ELECTROCHEMICAL SOCIETY—The Philadelphia section of the American Electrochemical Society held a regular meeting on Friday evening, October 6, at Soules's Café. The programme arranged was a discussion of the papers read at the eighth general meeting at Bethlehem, and the election of officers for the ensuing year.

TORONTO BRANCH OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—The twenty-third regular monthly meeting of the Toronto branch of the American Institute of Electrical engineers will be held at the Engineers' Club on Friday, October 13, at 8 P. M. The Institute paper, "Standardization of Enclosed Fuses," will be abstracted by Mr. R. G. Black. The twenty-fourth regular monthly meeting will be held on Friday evening, October 27, at the School of Practical Science. A paper entitled "Multiple Operation of Transformers," by R. T. McKenn, will be presented.

ELECTRIC RAILWAYS.

LOGANSPORT, IND.—The electric line from Lafayette to Battle Ground has been completed and is ready for use.

HUDSON, N. Y.—The Schenectady Railway Company has inaugurated its through service from Schenectady to Saratoga.

PARIS, IDA.—The work of installing the plant of the Bear Lake Railway and Electric Company has commenced at Paris.

WHEELING, W. VA.—The Wellsburg City Street Railway, with all its appurtenances, has been sold to the new Tri-State Traction Company.

MADISON, WIS.—President Warren Montgomery, of the Madison Traction & Interurban Company, announces that his company will build an interurban road between Madison and Stoughton next year.

PITTSBURG, PA.—The South End Connecting Street Railway has completed the deal for the rights in three townships south of Mount Washington, by filing with the county recorder notice of extensions to its line.

CLEVELAND, OHIO—The Cleveland Electric Railway Company has been granted a permit for the erection of an addition to the Washington street power-house. The structure will be one-story high and will cost $25,000.

EAST ST. LOUIS, ILL.—At a meeting of the incorporators of the East St. Louis, Waterloo & Chester Interurban Railway James P. Slade was elected president; A. B. Garret secretary, and E. T. Schoeurring, of Columbia, treasurer.

BLUFFTON, IND.—It is stated that the Muncie, Hartford City & Fort Wayne Traction Company, now operating from Muncie to Bluffton, has been acquired by the Widener-Elkins syndicate, which already controls more than half of the traction lines of the state.

HOLLAND, MICH.—An electric road connecting Saugatuck and South Haven is practically assured. Franchises have been granted in the village of Douglass and the township of Saugatuck. The track between Coloma and Saugatuck will be completed before winter.

DOVER, DEL.—Charles H. Le Fevre, attorney for the new trolley project to run from Clayton, Del., through Smyrna, on to Woodland Beach and thence down the state, has secured the right of way from the Smyrna town council through certain of the streets.

SAN FRANCISCO, CAL.—The directors of the Ocean Shore Railroad have completed the awarding of contracts for construction of the new coast road between San Francisco and Santa Cruz. The road will be eighty-two miles long, double-track, and will cost $2,000,000.

MARION, OHIO—The Cincinnati, Hamilton & Dayton Railroad has begun stringing poles along its branch line between Marion, Findlay and Deshler, preparatory to changing the road to an electric line. Work will go on as rapidly as possible, and it is believed that cars will be running within the next ninety days.

GLENS FALLS, N. Y.—The directors of the Fair Haven-Rutland railway have decided to extend their line from Fair Haven to Whitehall, a distance of nine miles. The proposed line will parallel the Delaware & Hudson lines, passing the Fair Haven fair grounds, through the village streets to the wharves on the lake front at Whitehall.

MARSHALL, MO.—The city council has granted the Central Electric Railway Company the right of way to locate and operate an electric railway through Marshall. The line proposed will run from Sedalia north to Miami. Ex-Senator E. D. Martin and T. F. Marshall, a capitalist of Blackwater, are interested in the promotion of the road.

JACKSON, MISS.—An agreement has been reached between the Jackson Street Railway, Light and Power Company and the Alabama & Vicksburg Railway, whereby the new power-house for the street railway will be located adjacent to the present power-house. The railway company has agreed to build a spur track to the site in accordance with the plans proposed. The plant will be one of the finest in the South, costing nearly $200,000.

SHEBOYGAN, WIS.—The Sheboygan Light, Power and Railway Company is figuring on plans for extensions and new suburban lines. One line will run northwest on the Calumet road to Cole's Park and Pigeon river, and will also reach the works of the Sheboygan Lime Company. The company will convert the Cole place into a park and amusement resort.

EMPORIA, KAN.—The Kansas City, Mexico & Orient Railway bond proposition was carried in three of the towns and townships in which it was submitted and lost in one. The company asked $40,000 in bonds from this town and $20,000 from Emporia, Jackson and Pike townships. The proposition was defeated in Pike township by a majority of thirteen.

MEMPHIS, TENN.—J. K. Newman, son of Isadore Newman, of New Orleans, principal holder of stock in the Memphis Street Railway Company, has spent some time in Memphis recently looking after improvements now being made in the system here. He states that $3,000,000 will be expended in making the system the most perfect in the South. Work has been completed on the new Raleigh road extension, and the old Raleigh road work will be undertaken at once.

CINCINNATI, OHIO—With the completion of the Western Ohio traction line (Findlay to Lima), there is now an unbroken trolley line from Cincinnati to Cleveland. The route through the state is from Cincinnati to Dayton, *via* the Cincinnati, Dayton & Toledo, from Dayton to Findlay to Pemberville, *via* the Toledo, Fostoria & Findlay and from Pemberville to Cleveland, *via* the Lake Shore Electric. The distance—294 miles—can be made with four changes of cars.

PERU, IND.—At a meeting of the directors of the Peru & Winona Interurban Company, at Warsaw, it was decided to commence building its line from Peru to Winona Park at once. The old Peru & Chili division of the Wabash road, nine miles in length, which has been leased by the interurban company, will be repaired at once and cars will be run over this section of the road before anywhere else. The company has succeeded in securing subsidies amounting to $110,000.

BEDFORD, IND.—The city council of Bedford has granted a franchise to the Indianapolis & Ohio Valley Traction Line Company for the construction of its tracks through the city. The line will run from Indianapolis to Evansville, passing through the counties of Marion, Johnson, Brown, Monroe, Lawrence, Orange, Dubois, Spencer and Warrick. A large portion of the route has already been surveyed. Work is to begin in May, 1906, and to be completed within two years.

FREMONT, OHIO—Outside capitalists and electric railway projectors have been in Fremont going over the proposed routes for a line between Fremont and Tiffin and Fremont and Port Clinton. The statement is made that the line from Tiffin to the lake will be built within a year. The projectors plan to absorb the local street car line now owned by Kerlin Brothers, of Toledo, and combine the plants of the Fremont Electric Light and Power Company and the Yaryan Heating and Power Company.

OKLAHOMA CITY, OKLA.—G. B. Stone has arranged with a syndicate at Toledo, Ohio, to finance the Oklahoma & Texas railway, to be built from Oklahoma City to Wichita Falls, Tex. The final survey has been made, and it is stated that the contract for construction work will be let at once. At a meeting the contract for the construction of the Oklahoma City, Lexington & Sulphur Springs Electric Railway was awarded to J. W. Maney, of El Reno. The line will be eighty miles in length and will cost over $1,000,000.

IDIANAPOLIS, IND.—The Louisville, New Albany, West Baden & French Lick Railway Company, proposing to build an electric traction line from New Albany to French Lick, has filed papers of incorporation with the secretary of state, with Thomas Taggart as one of the incorporators and directors. The line will be about fifty miles long, passing through the counties of Floyd, Harrison, Washington and Orange, and intervening towns. The principal office of the company will be in New Albany. The directors are: L. C. Davis, John F. Finley, George B. Dewees, B. H. Cravens, S. H. Braxton, Thomas Taggart, Lee W. Sinclair, O. S. Kline, W. A. Milton, John Sharp, John H. Leathers, Henry Ormsley, Henry Terstegge, Evan B. Stotsenburg and Marion W. Ripy.

TELEPHONE AND TELEGRAPH.

PIERRE, S. D.—The local exchange has been purchased by the Dakota Central system.

COLDENHAM, N. Y.—The Hudson River Telephone Company has completed its line to Berea.

HAMILTON, OHIO—The Bell Telephone Company has let the contract for a new $30,000 building.

WHEELING, W. VA.—The Western Union Telegraph Company is improving its system at West Alexander.

WEBSTER, MASS.—The New England Telephone and Telegraph Company has installed a farmers' line in Dudley.

LAFAYETTE, IND.—The city council of Frankfort has granted a franchise to the new Long-Distance Telephone Company.

BERKELEY, CAL.—The Pacific States Telephone and Telegraph Company is to spend $300,000 on an exchange building and plant.

NEW LONDON, IOWA—The Henry County Telephone Company is now connected with the Mississippi Valley Telephone Company.

WILMINGTON, DEL.—The Bell Telephone Company is installing a conduit from Wilmington to Philadelphia, Pa., in which to place its trunk wires.

COUNCIL BLUFFS, IOWA—The Independent Telephone Company has begun work on its city improvements, and also on its proposed line to Treynor.

BELLEVILLE, ONTARIO—The Independent telephone line between Bancroft, Coe Hill, Madoc Eldorado and Marmora has been sold to the Bell Telephone Company.

CHARLEVOIX, MICH.—The United States government telephone cable from Charlevoix to St. James, Beaver Island, in the middle of lake Michigan, has been laid.

GADSDEN, ALA.—The new telephone company, which was granted a franchise to erect a telephone system covering the entire city of Gadsden, will commence work at an early date.

WYNNE, ARK.—The Southwestern Telephone Company has commenced work on a line between Wynne and Harrisburg, thence to Jonesboro and other northern points, connecting finally with St. Louis.

MANKATO, MINN.—The Northwestern Telephone Exchange Company is extending its service in Mankato and the surrounding country. Many city and rural telephones are being added to the system.

BUFFALO, N. Y.—The Consolidated Telephone Company has bought the Elmira Telephone Company and the Marilla Telephone Company. The exchanges will be added to the Consolidated company's lines.

YARMOUTHPORT, MASS.—At the annual meeting of the Cape Cod Telephone Company, the old board of directors was reelected. F. Percy Goss was reelected president and Arthur G. Guyer, clerk and treasurer.

ARLINGTON, N. J.—The North Arlington council has adopted an ordinance granting to the New York & New Jersey Telephone Company the privilege of erecting poles and stringing wires in the streets of the borough.

NEW YORK, N. Y.—Telephone rates in The Bronx have been reduced, to go into effect October 1. A minimum service of 600 messages has been reduced from $54 to $48. The residential rate has been reduced from $48 to $39.

WILKESBARRE, PA.—An order has been placed by the Consolidated Telephone Companies of Pennsylvania for a new toll section, to be added to their Wilkesbarre exchange. This new section will require the services of four operators.

OWINGSVILLE, KY.—At public sale the Bath fiscal court's special commissioner sold the telephone franchise rights over every turnpike in the county to the companies whose lines now run over the roads. A rate of one dollar per mile was made.

SHERMAN, TEX.—At a meeting of the directors of the recently organized North Texas Telephone Company final arrangements were made for the construction of the proposed line from Sherman to Gainesville, *via* Southmayd, Pottsboro and Woodbine.

DOYLESTOWN, PA.—At a meeting of business men of Newtown borough a local telephone company was formed, with a capital of $5,000. Edward P. Hicks has been selected president of the new company and J. Herman Barnsley, secretary and treasurer.

RIPLEY, TENN.—A company has been organized for the purpose of putting in a telephone line from Halls, twelve miles north of Ripley, by way of Nankipoo to Edith. The incorporators are J. H. Bibb, G. N. Grear, L. F. Adams, E. Abernathy and A. B. White.

BALDWINSVILLE, N. Y.—The Patron Telephone Company has secured the line of Dr. F. P. Sinclair extending from Lysander through Jacksonville, Little Utica and Lamson terminating at Baldwinsville. The company will at once commence reconstructing the line between Lysander and Lamson.

DETROIT, MICH.—The Grand Ledge Telephone Company at its last annual meeting elected the following officers: president, Clark Smith; vice-president, D. Shadduck; secretary, G. M. Every; treasurer, D. Shadduck. The board of directors is composed of Clark Smith, D. Shadduck, D. G. Kennedy, G. M. Every and Joseph Otto.

PORTLAND, ORE.—The Sunset Telephone and Telegraph Company has bought the rural line owned by M. A. Crumbaker, for $7,000. This line runs through the country surrounding Colfax, and has a total length of 300 miles, with 240 telephones. It is patronized exclusively by farmers, but has connections at Colfax with the Sunset lines.

MANSFIELD, PA.—Lines have been erected for the combining of the York State Telephone system with the lines of the Farmers' Mutual, of Wellsboro, and Citizens' Mutual Telephone Company, of Mansfield. The latter two companies, which have long worked in conjunction, now operate over 2,000 telephones in all directions of Tioga, Potter and Bradford counties.

RUTLAND, VT.—The northern division of the New England Telephone and Telegraph Company will open an exchange at Felchville. An exchange was opened at North Troy September 1 with between fifty and sixty subscribers. Plans are complete for two more exchanges, one at Lowell and one at West Stewartstown, N. H. It is expected that these exchanges will be in operation in about a month.

FRANKLIN, IND.—William Mullendore and Frank and Victor Smith have disposed of their holdings in the Franklin Telephone Company, to Louis Hollweg, president of the Independent Telephone Company, of Indiana. F. Strickler, one of the stockholders in the Franklin company, retains his interest and will be placed in charge of the local plant. The new directors plan extensive improvements and much better service.

JONESVILLE, N. Y.—The Clifton Park Telephone Company at its annual meeting elected the following directors: Norman Van Vranken, Vischer's Ferry; J. K. Losee, Elnora; William Palmer, Grooms; Wesley Hall, Jonesville; Frank Hall, Burnt Hills; Wilard Garnsey, Round Lake; Dr. J. R. McElroy, Jonesville. The directors elected the following officers: president, Dr. J. R. McElroy; secretary, Norman Van Vranken; treasurer, J. K. Losee.

AURORA, ILL.—At the annual meeting of the Interstate Telephone and Telegraph Company the seventeenth regular quarterly dividend of one per cent was declared on the entire capital stock of the Interstate company. The report for the fiscal year ending June 30 also showed an increase of nearly $20,000 in the surplus over and above fixed charges, including interest and dividends, which was considered by the full board to be very satisfactory.

BINGHAMTON, N. Y.—The York State Telephone Company has signed a contract with the Candor Telephone Company, by which that concern enters into an agreement to cooperate with the York State company. The Candor company will soon extend its lines so as to cover all northern Tioga County. At present the lines touch Slaterville, Speedsville, Caroline, West Candor, Candor, Catatonk, Strait's Corners, and will soon be extended to Halsey valley. The agreement is now in effect.

ELECTRIC LIGHTING.

BURLINGTON, VT.—An electric plant has been put in operation at Jonesville.

PIKEVILLE, KY.—The Pikeville Electric Light Company is extending its service.

PARIS, ILL.—The street lighting system is being extended to the southern part of Paris.

PHILADELPHIA, PA.—Trappe and Collegeville will have a combination electric light plant.

ELMIRA, N. Y.—The Elmira Water, Light and Railroad Company is installing a 1,000-horse-power steam engine, to be used for lighting purposes.

AUSTIN, MINN.—The Austin water and electric light board reports to the council that the city plant must be improved at a cost of from $12,000 to $16,000.

BAY CITY, TEX.—The Bay City ice and electric light plant has been sold to Cave & Loyd, of Wichita, Kan. The plant cost in the neighborhood of $40,000.

PHILADELPHIA, PA.—The Beacon Light Company has awarded the contract for a new substation at Chester to relieve the pressure on the main lighting plant.

ELLSWORTH, ME.—George H. Grant, of Ellsworth, owner of the Hancock Water, Light and Power Company, at Hancock Point, is making plans for extending the system.

SALEM, OHIO—The entire plant and holding of the Salem Electric Light and Power Company have been sold to E. E. Beam, of Cleveland, and S. D. Gilbert, of Cincinnati.

TOPEKA, KAN.—A company headed by Topeka men and financed to the extent of $100,000, has made an offer to the Topeka city council for the purchase of the city's electric light plant.

MONTGOMERY, ALA.—The city engineer has issued a permit for the construction of a three-story building, to be occupied by the offices and salesrooms of the Montgomery Light and Water Power Company.

SYRACUSE, N. Y.—The completed plans and specifications for the electric light fixtures of the new court house have been adopted and approved by the building committee. In all 5,381 electric lamps will be employed.

BURLINGTON, WIS.—The proposed municipal electric lighting plant has been temporarily delayed by an injunction got out by L. J. Smith, who claims that the measure was not carried by the necessary two-thirds vote.

KIRKSVILLE, MO.—An application has been filed for a twenty-year franchise for a gas and electric light plant. B. F. Henry, Fred Grassle, Charles S. Sands, W. P. Foster, W. H. Foncannon and F. J. Storm compose the company.

CUMBERLAND, MD.—The town council of Midland has appointed a committee to confer with Superintendent J. S. Brydon, of the Consolidation Coal Company, with a view to having that company light the streets of Midland electrically.

BELLEVILLE, MO.—L. D. Turner, Henry A. Kircher and George Gauss announce that they have sold their interest in the Enid (Okla.) Electric and Gas Company and the Enid Gaslight, Heat and Power Company to H. M. Byllesby & Company, of Chicago.

GREENFIELD, IND.—The city council has voted to change the city's street lighting system to an alternating one. The electric plant is owned and controlled by the city, and the lamps now in use are the old-fashioned open kind. It will cost $2,500 to make the change.

EUGENE, ORE.—A. Welch, manager of the Salem electric plant, and representative of the Philadelphia syndicate which owns that plant and the one at Springfield, which furnishes light for Eugene, announces that the new owners will, in October, begin a twenty-four-hour service.

LARAMIE, WYO.—At a special meeting of the shareholders of the Laramie Electric Light and Fuel Company it was decided to sell the plant to the company represented by W. C. Sterne, of Denver, who has obtained a franchise and a contract for street lighting from the city.

SALEM, MASS.—Work is already under way on a trolley line from Boston to Lowell. It will run through Reading, Andover and Tewksbury. The running time between the terminals will be fifty-seven minutes, high speed being made possible by the tracks being laid through private lands instead of following the highways.

GREENCASTLE, PA.—Work has been started on the Greencastle electric light plant. A site has been purchased on West Franklin street and the power-house will be located there. A large amount of electrical apparatus has already arrived. The promoters expect to have the plant in operation by November 30.

GLENS FALLS, N. Y.—The contract for lighting the streets of this village for the next five years has been awarded by the Glens Falls village trustees to the United Gas, Electric Light and Fuel Company, of Sandy Hill. This company will light the village with thirty-three arc lights for fifty dollars per year per lamp.

WALTHAM, MASS.—The new power-house of the Waltham Gas and Electric Light Company, in course of construction, will be one of the largest outside of Boston. It will cover an area of 150 feet by 100 feet, and will be thirty-five feet high and fireproof. The contract calls for the building to be completed, the plant installed and in operation by January 1, 1906.

PAWTUCKET, R. I.—The ordinance granting the J. & P. Coats Company, Limited, the right to lay conduits in several streets of Pawtucket has been defaulted, as the company did not avail itself of the franchise within the time specified. The conduits were to have been for the purpose of transmitting electricity for heating, lighting and motive power from a private electrical plant on the water's edge. The venture would have involved the expenditure of half a million dollars.

NEW HAVEN, CT.—Stockholders of the Branford Lighting and Water Company have voted to sell the rights and franchises to the Consolidated Street Railway Company, thereby conforming to action recently taken by the majority stockholders. The Branford company has $300,000 in stock outstanding and $350,000 in five per cent bonds. The sale has given the Consolidated Railway the trolley line from East Haven to Branford, and it had to take the water and electric light plants as well.

LYONS, N. Y.—Certificate of incorporation of the Clyde Gas and Electric Company has been recorded at the Wayne County clerk's office. The company has $25,000 capital stock, divided into shares of $100 each, and is to manufacture gas and electricity for light, heat and power purposes. The directors are: Thomas W. Summers, of Ithaca; George S. Shepperd and William T. Morris, of Penn Yan. The corporation will take over the capital stock of the defunct Clyde Gas and Electric Company.

PERU, IND.—The committee having the municipal lighting plant of Peru in charge has issued a statement for the year ending June 30. The report shows that the receipts from the sale of electricity amounted to $22,694. The disbursements, including improvements and extensions, coal and freight, salaries, insurance, repairs and general expenses, amounted to $32,151.32. The city has 130 street lamps, and the average cost of maintenance is about twenty-six dollars a year. The committee reports that an expenditure of probably $30,000 would put the plant in good condition.

MARQUETTE, MICH.—Fifteen entries on lands located contiguous to the Manistee river, in Manistee County, lower Michigan, have been filed by Grand Rapids parties at the government land office. Their selection is significant of important water power developments. The lands are traversed the entire distance by the Manistee river, which forms into rapids for a distance of nearly a mile through high cliffs on both sides of the stream. It is understood that the rapids will be harnessed and a company formed for the purpose of building an electrical transmission plant, utilizing the water power. Nearly all the parties filing on the lands are members and relatives of members of the firm of M. B. Wheeler & Company, dealer in electrical machinery and supplies, Grand Rapids, which firm is said to be interested in a project to build a plant large enough to supply the city of Manistee with electric energy.

PERSONAL MENTION.

MR. H. LEE BRAGG, who for some years was identified with Pittsburg manufacturing interests, is now in charge of the department devoted to insulating materials of Emil Calman & Company, of New York.

MR. ROBERT McF. DOBLE, consulting engineer of the Abner Doble Company, San Francisco, Cal., has returned from a trip of several months through the Sierra Madre mountains on the west coast of Mexico and also in Colorado, where he was engaged in making examinations of several important hydroelectric long-distance power projects.

MR. ERRETT L. CALLAHAN, manager of the Prometheus Electric Company, New York city, has resigned to take charge of the electric-heating department of the General Electric Company, in the Chicago territory. Mr. Callahan has been very active in the electric-heating field for the past four years, having also been connected with the Simplex Electric Heating Company as assistant manager.

MR. G. W. APPLER, for the past two and one-half years superintendent of construction for the Northern California Power Company, of Redding, Cal., has been appointed general superintendent of the Rochester, Syracuse & Eastern Railway Company. This company will engage in very extensive construction, and Mr. Appler, it is understood, will have sole charge of the construction of all branches of the road.

MR. KENNETH B. THORNTON has been appointed operating engineer of the Canadian White Company, Montreal, Canada. Mr. Thornton is a past-president of the Canadian Electrical Association and a member of the American Institute of Electrical Engineers and the Canadian Society of Civil Engineers. After a three years' course in mechanical and electrical engineering at the Central Technical College, South Kensington, London, England, he returned to Montreal and entered the employ of the Royal Electric Company in the manufacturing, testing and draughting departments. Mr. Thornton has been intimately associated with the construction, operation and engineering details, in connection with the generation and distribution of light and power, for the Royal Electric Company and the Montreal Light, Heat and Power Company.

MR. CHARLES GARLAND.

MR. CHARLES GARLAND has recently resigned the position of secretary of the Westinghouse Machine Company, to become prominently identified with the Pittsburg Fireproofing Company, in the official capacity of vice-president and treasurer. Mr. Garland is a native of Ireland, and arrived at Pittsburg in 1883, at the age of fourteen, when he entered the employ of the Westinghouse Machine Company. He has since been continually associated with this company, advancing from a minor position until, in 1896, he was appointed assistant secretary and assistant treasurer. Two years ago he was advanced to the full secretaryship. The Pittsburg Fireproofing Company is a growing concern engaged in the manufacture of fireproof materials of many kinds. The works of the company are located at West Pittsburg, Lawrence County, Pa., and its main offices are in the Bailey-Farrell Building, Pittsburg, where Mr. Garland has his headquarters. Mr. Garland will continue his residence at Edgewood Park, Pa., where he is a prominent member of the Edgewood Club, of which for some time past he has been secretary.

ALLIS-CHALMERS PERSONNEL—Mr. M. C. Miller, who joined the Allis-Chalmers Company a little more than a year ago, has been made assistant to the sales manager, taking charge of all matters in that department not requiring the personal attention of the sales manager. Mr. Miller was formerly connected with the Westinghouse Electric and Manufacturing Company at Pittsburg. Mr. O. A. Stranahan, who joined the Allis-Chalmers Company on December 1, 1904, to become manager of the power department, assumed the duties of sales manager on September 1. His headquarters will be at Milwaukee. Mr. W. T. McCaskey, until recently manager for Agar-Cross & Company, of London, and for years identified with the Edison, Westinghouse and other electrical interests, will act as special representative for the Allis-Chalmers Company on considerations of equipping interurban roads, hydroelectric projects and other propositions requiring special attention. Mr. McCaskey is a native of Wisconsin, and was born in Richmond County in 1863. He entered the electrical field in 1882, when he took charge of the plant of the Eau Claire Electric Light and Power Company. Later he was connected with the Sperry Associate Electric Company, of Kansas City, and he operated the first electric lighting plant in Fort Worth, Tex., in 1885. From 1889 to 1894 he was on the Pacific coast connected with Edison and other interests. From 1894 to 1899 he was Chicago representative of the Standard Electric Company, and a general contractor. He then went to Buenos Aires, South America, to represent the Westinghouse Electric and Manufacturing Company and Agar-Cross & Company, where he remained until 1901. He was director in Spain and Portugal for the Société Anonyme Westinghouse until December, 1903, and manager for Agar-Cross & Company until May 1 of this year.

ELECTRICAL SECURITIES.

During the past week there was evidence of narrowing and professional speculation. Despite some hesitation and irregularity the market held fairly firm, with a decidedly good resistance to efforts to depress prices. Against the adverse factors introduced into the market's influences there can be cited the notable industrial and national prosperity. Large corporation earnings also indicate that the demand for all forms of product is unabated. Last week there were increases in dividends, not only in railroads and industrials, but in some mining institutions where an increase was not looked for. The present market will doubtless develop a condition which will be more or less a marking time for the next month or so. As soon as the situation becomes clear, however, there will undoubtedly be another revival, which will augur well for the spring balance.

ELECTRICAL SECURITIES FOR THE WEEK ENDING SEPTEMBER 30.

New York:	*Closing.*
Brooklyn Rapid Transit	72⅜
Consolidated Gas	187
General Electric	181½
Interborough Rapid Transit	215½
Kings County Electric	200
Manhattan Elevated	165
Metropolitan Street Railway	125⅞
New York & New Jersey Telephone	169
Westinghouse Manufacturing Company	195

The regular quarterly dividend of 1½ per cent has been declared by the directors of the New York & New Jersey Telephone Company. It is payable October 14 to stockholders of record October 5. The extra dividend of 1 per cent is paid in January.

The annual meeting of the stockholders of the Manhattan Railway Company will be held at the company's office in New York city, on Wednesday, November 8, at 12 o'clock noon. A board of directors for the ensuing year is to be elected, and three inspectors of election. The transfer books will be closed October 7, at 12 o'clock noon, and reopened November 9, at 10 o'clock A. M.

Boston:	*Closing.*
American Telephone and Telegraph	139
Edison Electric Illuminating	248
Massachusetts Electric	57
New England Telephone	136
Western Telephone and Telegraph preferred	95

Philadelphia:	*Closing.*
Electric Company of America	11⅛
Electric Storage Battery common	82
Electric Storage Battery preferred	82
Philadelphia Electric	9
Philadelphia Rapid Transit	28
United Gas Improvement	97⅞

It is stated that the gross earnings of the Electric Company of America for the eight months ended August 31 show an increase in gross earnings over the same period of last year of nearly $100,000.

Chicago:	*Closing.*
Chicago Telephone	138
Chicago Edison Light	140½
Metropolitan Elevated preferred	72
National Carbon common	62
National Carbon preferred	115
Union Traction common	9
Union Traction preferred	47

INDUSTRIAL ITEMS.

THE H. T. PAISTE COMPANY, Philadelphia, Pa., in bulletin No. 26 describes and illustrates a line of wooden and iron panel boxes, panel cutouts, cartridge cutouts and entrance switches.

THE EWING-MERKLE ELECTRIC COMPANY, St. Louis, Mo., in the October issue of the "Everbest" magazine contributes the usual collection of interesting sketches and data concerning the use of the apparatus handled by this company.

THE DE LA VERGNE MACHINE COMPANY, New York city, has issued a handsome catalogue descriptive of the Hornsby-Akroyd oil engines. In addition to the descriptive and illustrative matter there are given data relating to the operation of oil engines.

MR. CHARLES F. JOHNSON, 623 Ellicott square, Buffalo, N. Y., dealer in second-hand machinery and railway equipments, has begun the issuance of a monthly bulletin of equipments he has for sale. These bulletins are especially intelligently arranged as to classifications.

THE STROMBERG-CARLSON TELEPHONE MANUFACTURING COMPANY, Rochester, N. Y., reports having closed contracts for switchboards for the following places: Marathon, Wis.; Rose Hill, N. Y.; Watson, Mo.; Tolo, Ore.; Niagara Falls, South Ontario, Canada.

THE DE LAVAL STEAM TURBINE COMPANY, Trenton, N. J., will be pleased to send copies of its recent publication descriptive of De Laval steam turbine machinery. In addition to the descriptive matter there are several illustrations of the working parts of the apparatus.

THE JENNEY ELECTRIC MANUFACTURING COMPANY, Indianapolis, Ind., is distributing a leaflet descriptive of the motor drive for curved-plate shaving machines. The motor is attached rigidly to the end of the driven machine, and is furnished with enclosed heads to protect the windings and current-carrying parts.

THE AMERICAN STEEL AND WIRE COMPANY, Chicago, Ill., distributed a valuable souvenir in the shape of a copy of electrical tables at the street railway convention, Philadelphia, Pa., the week of September 25. Another publication which this company distributed described "Crown" United States soldered twin terminal rail-bonds.

MESSRS. ARNHOLD, KARBERG & COMPANY announce that they have opened a branch office at Newchwang, Manchuria, and will be prepared to execute orders for all Chinese products exported through that port, and will likewise extend to that region their customary business in shipping and the export of American manufactures and products.

THE H. W. JOHNS-MANVILLE COMPANY, 100 William street, New York city, has published a new 1,500 to 10,000-volt fuse bulletin descriptive of the "Noark" enclosed fuse and fuse devices. This catalogue is one of a series of three, the other two being devoted to 250-volt and 600-volt devices. The three books, when combined, describe a complete line of fuse devices suitable for all voltages.

THE ELECTRIC GAS LIGHTING COMPANY, 115 Purchase street, Boston, Mass., is distributing an attractive series of posters and bulletins descriptive of its various specialties. A novel feature of this distribution is a sample of special telephone cable. This is a reenforced weatherproof, three-conductor cable, the conductors being indicated by red, yellow and blue distinctive coverings.

THE CINCINNATI MILLING MACHINE COMPANY, Cincinnati, Ohio, has published a handsome catalogue descriptive of Cincinnati millers. In addition to the descriptive matter there are a number of handsome half-tone illustrations showing the construction and assembly of these machines. The machines are equipped for the electric motor drive, a number of applications being carefully described and illustrated.

THE LAIDLAW-DUNN-GORDON COMPANY, Cincinnati, Ohio, has published bulletin L-508, comprising thirty-two pages descriptive of the improved "Cincinnati" air-compressor. This compressor is characterized by a new and simple air-valve mechanism, by which the elasticity of poppet valves is combined with the quiet action, efficiency and high-speed qualities of positively moved valves. The compressors may be directly connected, without gears or belt, to electric motors and gas engines.

THE GLOBE ENGINEERING COMPANY, 229 South Main street, Dayton, Ohio, has established its office and stockroom and will engage in a general engineering and contracting business. The company is prepared to furnish anything pertaining to the construction and operation of waterworks, gasworks, electric light and power plants and street railway installations. There will be carried a full stock of electric light, bell, gas lighting and all other electrical supplies, as well as a complete line of high-grade direct and alternating-current motors.

THE MASSACHUSETTS CHEMICAL COMPANY, Boston, Mass., had a unique advertising feature in the shape of advertising placards displayed about its exhibit at the Philadelphia street railway convention last week. These were very handsome in design, and elicited considerable comment. Secretary Elwell and Sales Manager Duclos were kept busy answering enquiries concerning the company's improved insulating tapes. A large rubber mat, designed for the protection of switchboard operators handling 50,000 volts, excited a great deal of attention.

THE NORTHERN ELECTRICAL MANUFACTURING COMPANY, Madison, Wis., in bulletin No. 51 describes and illustrates the Northern ring-type generators and motors for power and lighting service. In addition to the descriptive matter and the illustrations of the standard motors there are shown several typical applications of these machines. Leaflet No. 145 calls attention to the Northern forge blowers. There are given two illustrations of the Northern spherical motor operating a Garden City forge blower. These blowers are made in sizes ranging from seventy-five cubic feet of air per minute to 425 cubic feet per minute, at speeds ranging from 2,200 to 1,600 revolutions per minute.

THE GOULD STORAGE BATTERY COMPANY, New York city, in bulletin No. 6 describes and illustrates the regulating battery in connection with combined railway and lighting plants. An example of the most recent storage battery practice is an installation made by the Gould Storage Battery Company for the Edison Electric Illuminating Company, of Topeka, Kan. This installation consists of 280 elements, type S-617, each having a capacity of 640 amperes for one hour; and a booster set which controls the operation of the battery, so that the generator load does not fall, even under extreme conditions, more than two and one-half per cent from any mean value for which the booster may be adjusted. The installation is described in this bulletin.

THE UNDERWRITERS' ENGINEERING AND CONSTRUCTION COMPANY, 34 West Twenty-sixth street, New York city, has issued a booklet entitled "A Declaration of Principle." This sets forth the plans upon which the organization of this company is based. The company will undertake the design and construction of reenforced concrete structures on a basis of cost plus a fixed sum, and is prepared to guarantee rapid construction combined with scientific design and high-class workmanship. The engineering of the company will be under the general supervision of Lewis J. Johnson. All matters on fireproofing will be submitted to Professor Charles L. Norton. On the construction side the company will enjoy such relations with Frank B. Gilbreth that it will have full use of the methods and organization which he has developed.

THE ABNER DOBLE COMPANY, San Francisco, Cal., announces that the University of Michigan has purchased the tangential water-wheel which it exhibited at the St. Louis World's Fair, and for which the company was awarded the grand prize. This wheel is to be installed in the hydraulic laboratory of the new engineering building at Ann Arbor, Mich., where it will be mounted, in connection with a duplex pump, for experimental purposes. Its output is 100 horse-power when operating under a head of 580 feet. The twelve-inch laboratory water-motors which the Abner Doble Company builds for technical schools and universities have attracted considerable attention among the engineering faculties of many of the leading educational institutions. Orders have recently been received from the University of Wisconsin, the Michigan School of Mines and the University of Toronto.